The
ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XVII No. 12 DECEMBER, 1956

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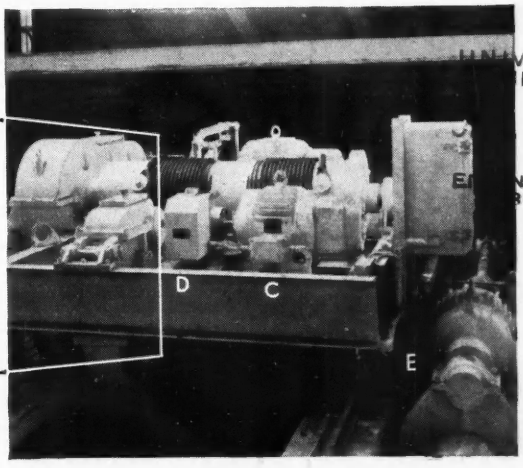
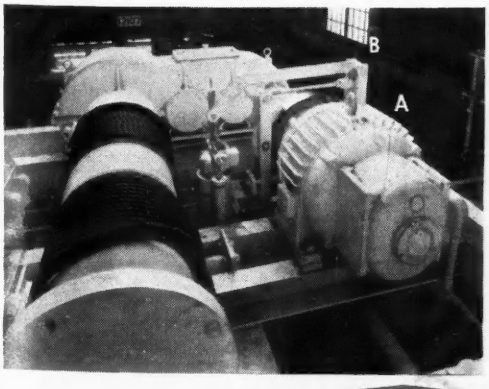


Metrovick equipment is well on top in this 10-ton Wharton overhead shop crane. The hoist is an 18-h.p. 720 r.p.m. M-V motor fitted with a thrustor-operated brake giving precise control with stable creeping speed on load. The need for inching is thus eliminated. Drives for the long travel and cross-traverse are M-V 10-h.p. 715 r.p.m. and 3-h.p. 700 r.p.m. type MZ slipring motors respectively. A 6-inch Perigrip brake operates on the cross traverse. Write for details of the range of M-V a.c. and d.c. motors, control gear and Perigrip electromagnetic brakes for crane drives.



In the illustration (left) A is the 18-h.p. 720 r.p.m. hoist motor fitted with Stacreep thrustor control B. The long-travel drive, motor E, is shown at the top of page. The 3 h.p. cross traverse motor is seen at C and the 6-inch Perigrip brake at D.

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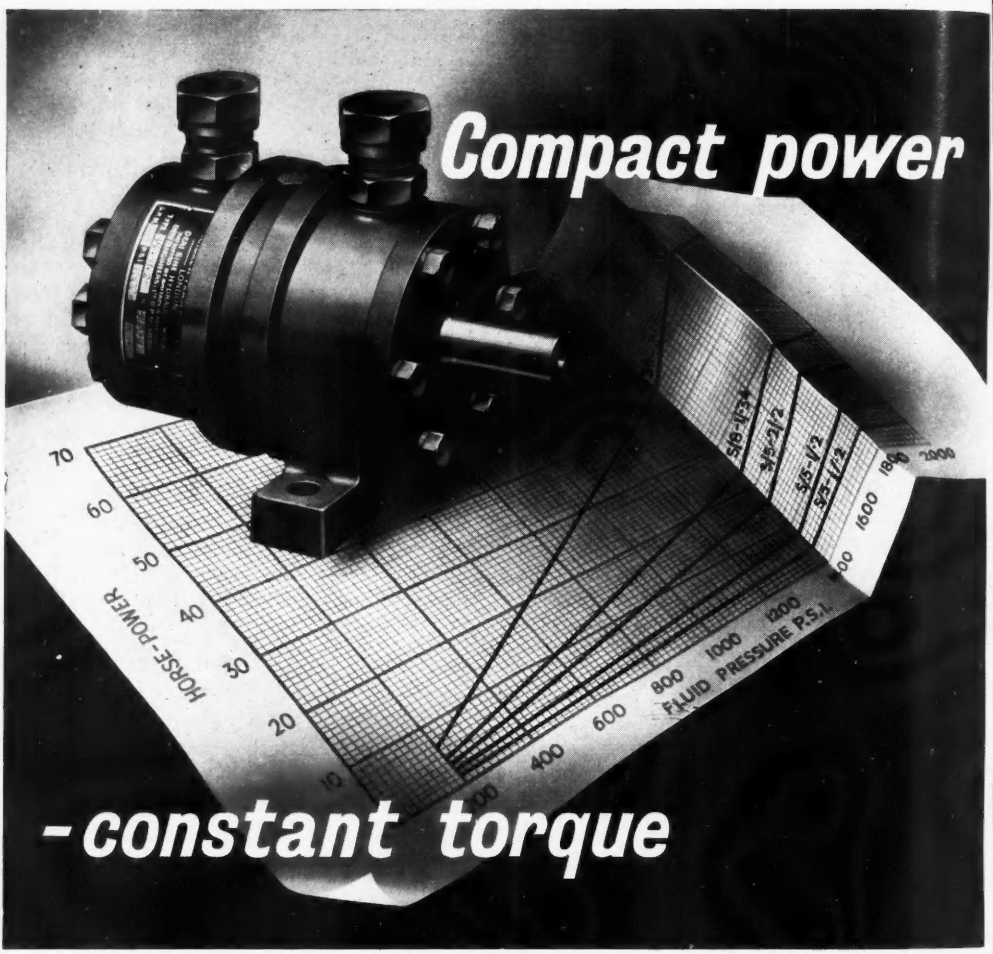

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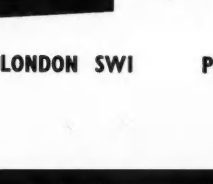

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REVIEW OF WORLD ENGINEERING PROGRESS

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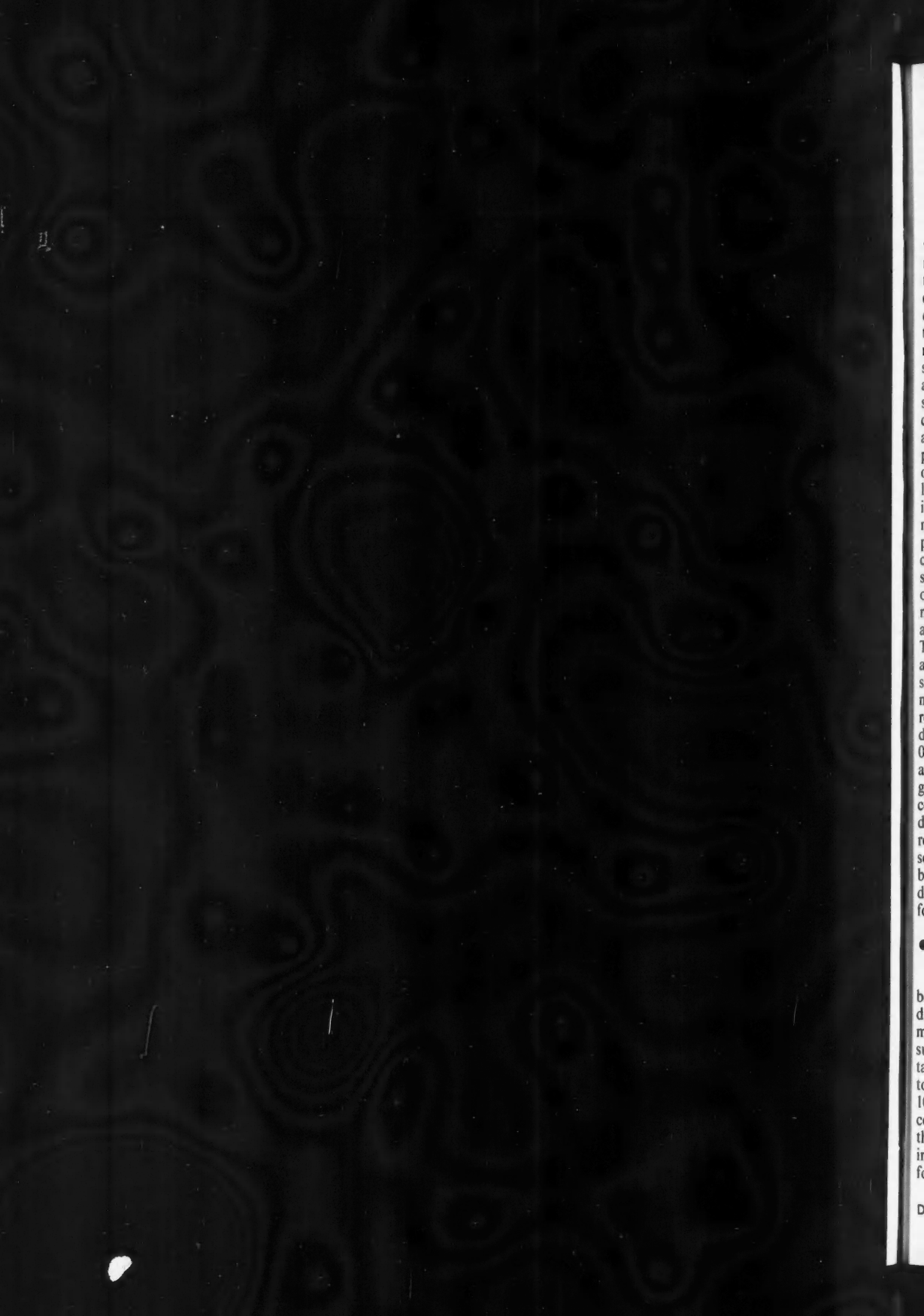

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *EXPENDABLE MOULDS FOR TITANIUM CASTINGS*

Because titanium is so reactive with the atmosphere and the usual refractories, the standard foundry techniques for melting and casting cannot be used. There are two distinct problems involved in titanium casting, the first being the selection of the melting technique and the second the development of a suitable mould material to minimize contamination. The melting problem has been studied sufficiently, so that metal can be melted out of contact with refractories. For corrosion-resistant applications, alloys with satisfactory chemical properties, but relatively low ductility, can be obtained by the employment of comparatively low-cost induction-melting techniques. There is little contamination of the metal when machined graphite moulds are used, but mould preparation is slow and costly, and the moulds can be used only a few times and are limited to simple shapes. A recent development consists of the use of powdered graphite as a base material, in order to circumvent the disadvantages of the machined graphite mould. The new type of mould is inexpensive to produce and can be moulded to produce any desired shape. Castings produced in these expendable moulds are reported to exhibit negligible surface reaction. In a section of 1 in. diameter, the depth of surface contamination was found to be 0·01 in. from a machined graphite mould and about 0·04 in. when using the expendable graphite-powder mould. No greater depth of contamination is shown in a section of 2 in. diameter. The hard contaminated layer may be removed by pickling with a 3% HF/10% HNO_3 solution in water, or by sand- or steel-grit blasting. This contaminated surface layer is no deeper than the oxidized surface layer of many forgings.

● *ULTRASENSITIVE TELEVISION-CAMERA TUBE*

A new television-camera tube, expected to be some 100 times more sensitive than present-day camera tubes, is now in course of development. The tube has a caesium-antimony photo-surface, on which the image is focused ; a target consisting of a thin, fine-mesh screen, to which are attached a layer of aluminium foil 1000 angstroms thick and a layer of semiconductor material several microns thick ; and the standard gun-deflection system found in image-orthicons. In operation, the image focused on the photo-surface produces electrons which are accelerated to the target by approximately 20,000 V. The electrons progress through the target and cause an avalanche effect to take place in the semiconductor. Since the semiconductor has previously been uniformly charged by the scanning electron beam, the electrons progressing through it discharge a minute segment. On reaching this segment, the scanning beam recharges the surface, generating a pulse in the output circuit. The unit is said to be capable of detecting light levels of 0·00005 foot-candle, but it is expected that by the use of a newly developed image multiplier tube sensitivity may be further increased to approximately 0·000001 foot-candle. The operating principle of the image multiplier is based on the fact that electrons impinging on a thin film of potassium chloride deposited on a supporting thin mesh will cause approximately 10 electrons to be emitted from the opposite side. By placing four of these films behind each other, a gain of 10^4 in the number of electrons may be obtained. A magnetic field is used to focus the electrons as they travel between the films. This image multiplier may be used for either direct viewing or it may be placed between the photo-surface and target of the camera tube, eliminating the phosphor screen used for direct viewing.

● *CURRENT MEASUREMENT BY MEANS OF THE FARADAY EFFECT*

Unlike other methods in use to-day, a new method of measuring electrical currents, developed in Russia, is stated to be totally unaffected by voltage or frequency, and may be said to be inertialess. It is, therefore, a substantial advance in measuring high-frequency currents, impulse currents, and continuous currents of very high voltages. A light beam is used as a " carrier link " between the high-voltage conductor and the pick-up unit. The light beam is modulated directly by the current

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to be measured, and in this modulated form falls on a photo-cell, the voltage across the load resistance of this cell being measured by a recording or indicating instrument. The physical phenomenon known as the Faraday effect, used to modulate the light beam, is the rotation of the plane of polarization by a magnetic field. The measuring device, therefore, consists of a light source, a condenser, a polarizer (polaroid screen), a modulator, and an analyser, the light throughput of which is picked up by a photo-electric amplifier. The latest variant of the modulator consists of a system of reflecting prisms attached to the high-voltage conductor. In this way the light beam is made to traverse a long distance within the magnetic field with the minimum of inductive resistance in the measuring system. This is possible because the Faraday effect does not depend on the direction of the light.

Earlier modulators consisted of a glass tube filled with benzole surrounded by a coil carrying the current. An accurately stabilized high-pressure mercury lamp is recommended as the light source. The frequency response between 0 and 680 kcs has been found perfectly linear.

● *ELECTRO-EROSION DEVICE FOR COPY-MACHINING*

A particularly promising new field of application would appear to lie in the use of the spark-erosion technique to copy-machining devices for producing an exact replica of a master pattern. An especially attractive feature of the spark method in this connection is that the tool-guiding mechanism will not be submitted to tool thrust, since the action of the spark-erosion method does not rely on the exertion of mechanical cutting forces. However, in the mechanism of conventional copying devices, the wear of the tool is negligible and easily taken care of, so that exactness of reproduction is ensured, while in spark machining the electrode which takes the place of the cutter is subject to considerable wear. Unless special provision can be made to maintain the sparking point of the electrode in correspondence with the datum position of the tip of the stylus passing over the contour of the master pattern, exact reproduction is quite impossible. It is therefore interesting to note that a recently published patent specification describes a spark-erosion copying device in which this difficulty is overcome by the use of a special sensing mechanism incorporated in the electrode holder. This automatically compensates the wear of the electrode, maintains its cutting point in exact correspondence with the stylus location over the master pattern, and prevents the removal of further material from the workpiece, once its contour corresponds with that of the master pattern.

● *PEARLITIC MALLEABLE IRON CONTAINING BISMUTH AND BORON*

The usual form of pearlitic malleable iron is unsuitable for section sizes much greater than $\frac{3}{4}$ in. in thickness. A round section, $1\frac{3}{4}$ in. in diameter, is about the limit which can be cast free from mottle. It has been found that, by the addition of 0·025% bismuth and 0·003% boron, a section up to 5 in. in diameter can be cast without mottle. This characteristic makes such an iron suitable for crankshafts or other heavy-section castings. It is reported that the new composition, which is stated to be covered by a patent, was discovered in the course of an investigation concerned with the development of a faster-annealing malleable iron. The intention was to raise the silicon content to speed up the carbide decomposition and then to introduce a carbide stabilizer which would counteract the graphite-forming action of the increased silicon content during solidification, but which would not interfere with carbide decomposition during annealing. It was found that tellurium acts as such a stabilizer. Subsequently, it was discovered that bismuth would act in the same way and would produce more uniform results. Crankshafts for automobile engines are already being produced from this material, using a shell-moulding process, which enables the crank-webs to be cast with sufficient accuracy to make their machining unnecessary. It is claimed that an additional saving results from the fact that, in general, the machinability of the pearlitic malleable iron is much better than that of steel.

● *SLIP DAMPING OF TURBINE BLADES*

Service failures of gas-turbine blades can in many cases be attributed to the high stresses accompanying resonant vibration. These stresses reduce the fatigue life of the blading. Failures so induced have been matters of concern to the designers of aircraft power plants, and it has been thought that any significant increase in the damping present in the blade structure would operate to reduce vibration stresses and to increase turbine life. Apart from aerodynamic damping, the mechanisms of energy dissipation available to the designer are internal damping inherent in the blade material and slip damping. The latter type of damping is based on the fact that energy of vibration may be dissipated by microscopic slip on interfaces where machine elements are joined in a press fit. A recent research report examines slip damping as a possible agent for reducing turbine-blade resonant stresses and prolonging turbine life. A general theory of slip damping is developed, an expression for the energy loss per cycle of oscillation is found, and the predictions of the theory are compared with the results of controlled

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experiments. It appears that the theory is in satisfactory agreement with experiment and measurements made on turbine blades. The implications of the general theory in the design of turbine blades are discussed in the report. It appears that slip damping is capable of being an effective agent in reducing resonant stresses, especially in the " stall-flutter " condition, where aerodynamic damping is inadequate. It is not surprising that corrosion fretting accompanying slip has been suggested as a possible deterrent to the effective use of slip damping. In the present state of knowledge it does not seem possible to decide this question dogmatically, and exhaustive investigations of this aspect appear to be indicated.

● ***HALIDE PROCESS FOR MAKING NODULAR IRON***

By employing a new process, easily machinable and ductile nodular iron can now be produced without annealing and without introducing other elements with the nodulizing agent. In the new process, instead of using active metals such as sodium or magnesium as nodulizing agents, the halides of these metals and a reducing agent such as calcium silicate are added to the molten iron, the chloride being the preferred halide. When it is reduced to the metal, the active nodulizing element is stated to be formed in atomic fineness and to be absorbed immediately in the molten bath. In contrast, solid magnesium does not disperse, but forms a reactive vapour at the temperature involved. It is reported that all the halides of nodulizing metals, such as sodium, magnesium, lithium, strontium, barium, rubidium and cerium, have been successfully utilized experimentally ; however, because of their low cost, the chlorides have been chosen for industrial application. It is reported that the new process has proved its value by several months of commercial application in the foundry, the as-cast nodular irons having consistently displayed high strength and ductility. They can be flame-hardened or solution-treated and seldom exhibit less than 10% elongation in 2 in. The residual magnesium content is said to be low, in no case exceeding 0·03%, while complete nodulizing has been accomplished with as little as 0·015%.

● ***MICROCINEMATOGRAPHIC TECHNIQUE FOR ANALYSING METAL FATIGUE***

A small fatigue-testing machine equipped with a motion-picture camera for filming the microscopic features of the metal surface during fatigue fracture has been constructed. The base of the machine is a block of steel designed to fit the stage of the microscope, and machined at the top to a shallow U-shape, a horizontal collet for holding the test specimen being inserted through the upper part of the block. Two small eccentric cams are mounted at the ends of a motor-driven shaft passing through the lower part of the base, so that cam followers can transmit the load to the ends of the collet. The metal specimen to be filmed is pressed into the collet, and an alternating torsional load is applied through the cam followers by the cams, which are mounted 180 deg. out of phase. A 0·01-in. hole drilled in the top surface of the specimen provides a focusing target for the microscope. Any fatigue failure occurring will tend to develop around the hole and will thus be in the field of the microscope. The camera is attached to the principal eyepiece of the microscope, and a second eyepiece permits visual observation. The film is advanced at regular intervals by a synchronous motor-driven cam which actuates the single-frame button of the camera, the shutter of which is adjusted to close only during film transport. Because the speed of the fatigue-testing machine can be adjusted with respect to the movement of the film, the number of stress cycles per frame can be varied, depending on how rapidly changes are taking place in the surface of the metal.

● ***NEW METHOD OF TITANIUM PRODUCTION***

A recently published patent specification describes a novel method for the production of titanium billets by reacting titanium tetrachloride with liquid magnesium. The process is carried out in a cylindrical reaction chamber, the bottom of which consists of an end-plug operated by a hydraulic jack and supports the lower extremity of the billet. A molten salt bath is prepared in the reaction chamber by introducing magnesium chloride through a delivery pipe and then heating the reactor to melt the anhydrous magnesium chloride and establish an average bath temperature of about 800°C. After purging the system of oxygen, helium is introduced into the reactor vessel, and titanium tetrachloride is then introduced from a vaporization chamber which is kept at a temperature between 500 and 600°C, the feed into the reactor being held between 300 and 400°C. The next stage of the process consists of introducing magnesium in the form of sticks through an air lock, while the supply of titanium tetrachloride is maintained as the reaction proceeds, i.e., as titanium metal is formed. By means of a reciprocating ram with a downward thrust, the metal is collected and compacted in the lower part of the reactor. The titanium billet thus produced is claimed to contain from 85 to 90% titanium and only 15% entrained salts. By operation of the movable plug in the reactor bottom the billet is then removed from the reactor. In order to produce pure titanium, the billet is used as an electrode in an arc furnace, from which the volatilized salts are removed by scavenging the furnace with argon.

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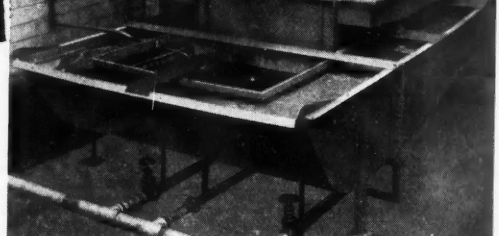
Left. *"Airflo" Wet Dust Arrester at the Forgings Division of High Duty Alloys Limited at Redditch.*

Below. Showing clear water in inner tank and sludge outside for easy "scumming".



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• *ECONOMICAL PROCESS FOR PRODUCING HOLLOW CEMENTED CARBIDE DIE INSERTS*

Cemented carbide inserts for drawing or extrusion dies are known to outlast many times the best alloy steels, and in many cases the use of a carbide die or insert is either one of necessity or of economics. A cemented carbide die or insert is considerably more expensive than a steel die, and there is undoubtedly a very pressing need for improved fabrication techniques for reducing the cost. In a recent patent, however, a method is proposed in which hollow inserts can simply and economically be produced with their opening moulded to the required contour. The basis of the process is the use of a mould with flexible walls, which is then subjected to external hydraulic pressure by suitable equipment, thus producing a compact of the shape of the required insert. By means of this process, dies with intricate internal contours can be pressed to shape with maximum surface hardness, thereby improving quality and reducing die costs. In addition, after sintering, very little finish grinding is required to bring the die to exact dimensional specifications. The die insert can be made in one tubular piece but, if desired, it can be made as two semi-cylinders, so as to facilitate internal grinding. If the flexible mould is constructed from rubber or some rubber-like material, its wall thickness should be sufficient to hold the charge of comminuted material without distortion or collapse. In the manufacture of tubular parts with irregular or intricate internal or external wall contours, it is claimed that tremendous savings can be effected, compared with the older method of machining or grinding the article from a hardened sintered block.

• *SEMICONDUCTOR-TYPE NUCLEAR BATTERIES*

In the December 1954 issue of the Blue Pages, reference was made to the development of a novel atomic battery. A newly published patent specification describes in more detail the construction and operation of such an atomic battery of the semi-conductor type, in which the energy of nuclear radiation is converted into useful electrical energy. This battery includes a source of high-energy nuclear radiation, such as a quantity of polonium and uranium, strontium-90 or tritium, or cobalt-60, etc. The semiconductor irradiated comprises a *p-n* junction device, either of the grown type or of the alloy type. If *n*-type germanium is chosen for one region of the device, the adjacent *p*-type region may, for example, be lead, antimony, or gold-antimony. If strontium-90 is used as the radiation source, a germanium device of 0·05 in. thickness will absorb substantially the available radiation. In an irradiated silicon device, twice this thickness will be required. Comparative figures for germanium and silicon batteries indicate that the silicon battery produces a higher open-circuit voltage, while the germanium battery produces a higher short-circuit current, owing to its lower internal impedance. However, as the open-circuit voltage of the silicon battery is considerably higher, so, too, is its power output. The junction device is, of course, so located in the path of the high-energy radioactive emission that as much as possible of the incident radiation is absorbed in the junction region. A particularly effective arrangement uses a cylindrical device which has an inner and an outer region, with a central cylindrical bore for the radioactive material.

• *NEW MAGNESIUM-THORIUM ALLOY*

There is only a limited number of materials which are suitable for frame and panel constructions to be used at ambient temperatures from 500 to 700°F. When, for reasons of stiffness against buckling, comparatively thick sections are required, the lightest material for a given volume will be the most suitable. Until recently, the only alternatives to aluminium have been alloy steels. These have a good strength/weight ratio, but excessive weight is required to provide the requisite stiffness, because critical buckling loads in panel members are proportional to Young's modulus and the cube of skin thickness. Hence, the availability of materials with a higher modulus/weight ratio is becoming important. A newly developed light material, possessing useful properties at moderately elevated temperatures, is stated to be a magnesium alloy containing 3% thorium and 0·75% zirconium. Having a density one-quarter that of steel, this alloy retains high strength and elastic modulus up to temperatures above 600°F. Furthermore, it exhibits good creep resistance and can be cast, heat-treated, and welded. It is available in sheet and plate form. Heat treatment of the alloy in sheet form requires a special furnace providing a sulphur dioxide atmosphere ; special racking, straightening, and pickling operations are also called for. Fusion welding likewise requires a number of special techniques, in order to ensure high-quality welds. The as-received material requires further pre-weld cleaning to remove a tenacious oxide film, this being effected by solvent cleaning, followed by a dip in a solution of 20% chromic acid and 3% potassium nitrate at room temperature for 10 sec, and rinsing in hot water.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.

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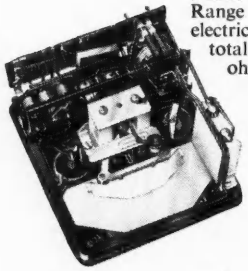

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THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XVII No. 12 DECEMBER, 1956

Safety and Health Precautions in Welding Operations

(From *The Welding Journal, U.S.A.*, Vol. 35, No. 10, October 1956.)

Quite apart from the considerable numbers of fires attributable to cutting and welding operations, other factors involving danger to those engaged in such operations include serious explosions, burns, the possibility of electrocution during electric arc welding, and exposure to noxious fumes, etc.

(1) SAFETY IN INSTALLATION AND USE OF WELDING EQUIPMENT*

Specific details for the design, erection, and installation of acetylene-generator buildings, distributive piping systems, or manifolding of oxygen and acetylene cylinders are beyond the scope of this paper. However, stress is placed on the most obvious, but least suspected, operating conditions which can cause injury, death, and unwarranted replacement cost where buildings and/or their contents are concerned.

Welding and Cutting Operations

The location of an acetylene-generator building should be carefully checked and approved. In addition, there must be full compliance with local regulations, which in many instances are completely overlooked or ignored. The fact that mixtures of inflammable acetylene gas and air are extremely explosive should never be overlooked. Gas leaks, smoking in the area, or adjacent sources of possible ignition should always be guarded against. In this connection, it is reasonable to question to what extent operating personnel are properly instructed regarding the inherent hazards involved, and how often operator technique is checked by supervisors or safety engineers. The fact is that operators readily develop malpractices, and these, coupled with the labour turnover experienced in many industrial installations, call for more serious attention on the part of management.

With regard to oxygen and fuel gas cylinders, it has been found desirable to store full cylinders outdoors or on loading platforms, protected against the weather, or indoors if space permits. Separate areas for full and empty cylinders, chained or separated by structural steel members, should be mandatory, as also should be the storage of oxygen cylinders in separate areas and away from acetylene cylinders ; large wall signs, designating the use to which the separate areas have been allocated. should also be obligatory. So-called empty cylinders are never completely empty and, where oxygen cylinders are concerned, there is potential danger.

The most prolific and usual abuses of protection involving cylinders, particularly full cylinders, are:—

(1) Protective caps not tightly secured in place.

(2) Connection of gas cylinders to equipment by means of rubber hose, without any provision for preventing cylinders from falling on employees or on adjacent equipment, or, as a result of a fall, destroying valuable equipment.

(3) The oxygen in a full cylinder is under a pressure of approximately 2200 psi. Disastrous experience has demonstrated that a fallen cylinder with an unprotected valve, which may be snapped off as a result of the fall, can take off like a rocket, penetrating brick and concrete walls, and capable of destroying life and property. A typical example reported concerns a case where compressed-gas cylinders, some without protective caps, were being offloaded from a truck. One of these cylinders fell to the ground, shearing off the valve from the head of the cylinder and releasing its contents. The cylinder immediately became a jet-propelled projectile, rose 12 ft, and went through a window, levelling a pile of drums inside and ricocheting into two work-benches in the plant, but fortunately missing a number of employees.

(4) Transfer of cylinders from one job to another on hand trucks, unchained and without valve caps in place.

(5) The use of empty cylinders as rollers under equipment. A typical case reported is that of empty oxygen cylinders being employed as rollers to facilitate the transfer of castings from one metal-working machine to another.

With regard to arc-welding and cutting operations, some of the major items of exposure to be considered under this category are as follows :—

(1) Shock and/or electrocution caused by improper or lack of grounding, frayed cables, and water puddles.

(2) Possibility of explosion or ignition of adjacent inflammable vapours.

(3) Potentiality of serious health exposures with possible fatal results, caused by the decomposition of carbon tetrachloride, trichlorethylene, and perchlorethylene. One of the dissociation products from any of these materials is phosgene, a poisonous gas. In a confined area, trouble should be anticipated.

(4) Eye injury to helpers, foremen, or other personnel who may be in the welding area.

(5) Fires resulting from the use of :—

(a) Combustible tarpaulins. There is no legitimate reason for this, since impregnated fire-resistant tarpaulins are available. This potential exposure may by completely eliminated by the use of portable or fixed shields or partitions made of metal or non-combustible material.

(b) Absence of fire watchers during welding repairs.

(c) Improper and/or inadequate fire-protection devices.

(d) Repairs adjacent to or in areas where combustible or inflammable stock is stored or used.

(6) Electric burns.

(7) Burns from flying sparks, particularly from spot-welding units. In this connection the appropriate American Standard states that the hazard of flying sparks must be eliminated by installing a shield guard of safety glass or cellulose acetate at points of operation, and that additional shields or curtains must be installed, as neces-

* By B. Postman, pp. 1021-1025, 5 illustrations.

sary, to protect passers-by from flying sparks. It would, however, be interesting to carry out a check in spot-welding shops to determine the extent of compliance with this important recommendation.

With regard to burns, these usually occur on the hands or arms, if unprotected by gloves and sleeves. They may also occur on the chests of female employees with V-neck blouses. Personnel with long hair should be provided with, and required to wear, protective caps.

(8) The welding or cutting of containers which may have held inflammable solvents. In this case, all recognized specified safety precautions, e.g., purging and the use of explosion meters, should be rigidly observed.

Nevertheless, whether containers have held inflammable materials or not, certain malpractices should be carefully guarded against, as the following example, involving a gas-welding operation, will show. In this particular case, the welder, after leaving a tank he was welding to go to lunch, removed his gloves and helmet and hung his torch over the inside of the manifold opening. After his return, he entered the tank and struck a spark to light his torch. There was a violent explosion, catapulting the welder into the air and causing fatal injuries. The explosion was apparently caused by the ignition of gas which had entered the tank via a leaking hose connection at the torch, the specific malpractice in this case being the hanging of the torch on the inside of the manifold opening, instead of outside.

Weld Examination

Welders in some shops may be exposed to a serious hazard caused by the use of X-rays, radium, and radioactive isotopes utilized for the inspection of welds, in accordance with some specification requirements. Although the welders themselves do not handle any of these potent and dangerous materials, they may be exposed to stray radiation, where weld examination is performed in open shop areas, not completely shielded against leaks of stray emanations of beta or gamma rays.

Methods of control are as follows :—

(1) A periodic check with proper instruments, to evaluate the presence or absence of stray radiation. Such data should be recorded on a checking form for future reference.

(2) Any weld examination of longitudinal or girth seams of tanks or similar units by means of a stationary X-ray unit located under the carriage supporting such units, or the use of portable X-ray equipment or units now utilizing radioactive isotopes, should, if at all possible, be performed at night. This will then involve only the X-ray technicians, who are usually properly indoctrinated and protected by the use of pocket dosimeters and/or film badges.

(3) In the final analysis, distance is the safest control available. If items (1) and (2) above cannot be performed as indicated, then welders in areas adjacent to the test areas should be removed during the short period required for the examination of the item being checked.

(2) HEALTH ASPECTS OF WELDING*

Although adequate personnel protection and the use of sufficient and correctly applied ventilation have been found to offset any potential health hazards associated with welding processes, it is desirable to have some knowledge of the particular hazards inherent in different procedures, and these are discussed in the following.

* By B. L Vosburg and J. J. Ferry, pp. 1015-1020, 6 illustrations.

Low-Hydrogen Welding

The fumes produced by electrode coatings containing fluorides, as used in the low-hydrogen method of minimizing oxidation in welds, contain solid particles of fluoride salts, the concentration depending on the amount and type of fluoride in the flux, the rod size, and the amperage used. Under some conditions, gaseous fluorine compounds, probably hydrogen fluoride, may be produced, but normally in extremely small amounts.

Exposure to excessive concentrations of fumes containing fluorides will produce nose and throat irritation, and chronic nose-bleed has been reported. Frequently, a tolerance to the irritation may develop, but a cessation of complaints does not necessarily mean that conditions are safe. Absorption of excessive amounts of fluorine compounds through the lungs may produce fluorosis (a change in bone structure) or other systemic effects. The generally accepted maximum allowable concentration of fluorine as fluorides is 2·5 milligrams per cubic metre of air ; for hydrogen fluoride, three parts per million.

The fluxes used in welding stainless steel, nickel, and aluminium usually contain fluorides. The same general comments as for low-hydrogen covered electrodes apply.

Tests have shown that the fumes from stainless-steel electrodes may contain approximately 6% of chromates, calculated as CrO_3. When concentrations of soluble chromates exceed the maximum allowable concentration of 0·1 milligram of CrO_3 per cubic metre of air, inhalation of such chromates will produce irritation of the upper respiratory tract.

Submerged-Arc Welding

In submerged-arc welding, the arc is covered with a rather heavy layer of granulated flux which normally shields the arc. These fluxes also contain fluorides. Tests have shown that, when the flux is heated to the melting point, hydrogen fluoride or other gaseous fluorine compounds will be produced. The amount of hydrogen fluoride produced depends on the amount of flux heated and the temperature reached. Little difficulty has been noted during machine welding, where the size and position of the arc are carefully controlled. There have been complaints of nose and throat irritation during manual welding, particularly where large amounts of metal were being deposited.

Inert-Gas Metal-Arc Welding

The inert-gas metal-arc-welding process has introduced some new and unusual potential hazards. Ultra-violet radiation is increased approximately tenfold, depending on the current density, the type of metal being welded, and the particular inert gas used. This calls for additional precautions, both in protecting the skin and eyes of the welder and in shielding nearby personnel. Dark —preferably wool—clothing must be worn to cover all exposed skin surfaces. Tests by several authorities have shown that adequate eye protection from ultra-violet radiation is given by the welding lenses recommended for the various amperages of ordinary arc welding. The increased brightness from visible light, however, may make it necessary for some people to use lenses that are one or two shades darker, in order to prevent eye strain and depletion of the visual purple which is the cause of snow blindness. It is worthy of note that intense ultra-violet light may cause the disintegration of cotton clothing. Ozone, which may be hazardous, of course, in any type of welding under conditions of inadequate ventilation, is produced in larger amounts by the inert-gas metal-arc-

welding process. The amount produced will vary with the type of metal and gas used, and also with the current density and the atmospheric humidity. The recently established threshold limit of ozone of 0·1 ppm is quite commonly exceeded. However, even though respiratory irritation has been reported, serious illness has not been encountered, probably due to the fact that the welding-arc time is intermittent and usually less than 50% of the working day. It has also been shown experimentally that minor lung exposures to ozone afford additional protection against more serious exposures.

Still another potential hazard in the inert-gas metal-arc-welding process relates to the ready conversion of certain chlorinated hydrocarbons to phosgene under the intense actinic radiation. For example, trichlorethylene, commonly used in degreasing operations, may give rise to a dangerous concentration of phosgene, even when the concentration of the trichlorethylene vapours is too low to be detected by the sense of smell. Thus, degreasing and inert-gas metal-arc-welding jobs must be separated physically. It may suffice to accomplish this isolation by ensuring that a positive air current passes from the welding area towards the degreaser.

Because inert-gas metal-arc welding produces high temperature, larger amounts of metal fumes may be encountered, the amount depending chiefly on the current values and the type of metal used. These high concentrations of metal fumes will commonly demand local exhaust ventilation of a type which does not disturb the inert-gas mantle. It is noteworthy that a number of welders have become ill when exposed to copper fumes.

There has been considerable anxiety, originating with theoretical physicists, in the use of thoriated tungsten electrodes in the inert-gas metal-arc-welding process. The best published information, however, indicates that there is no hazard from the inhalation of thoria particles, except possibly if welding is carried out in a confined space. An added precaution should be taken in dressing a thoria-tungsten electrode on a grinding wheel, by ensuring that it is sufficiently well ventilated to remove all the dust produced, or else by keeping the tip of the electrode under water during dressing.

When carbon dioxide is used as a shielding gas, some of it is decomposed by the arc to form carbon monoxide, the amount depending on the arc temperature.

Atomic-Hydrogen Welding

In this process, hydrogen is passed through an arc drawn between two tungsten electrodes. The hydrogen, by disassociation and reassociation, greatly increases the amount of heat available, and also serves to blanket or shield the weld from the air. Filler metal, where needed, is fed into the arc separately. The hazards associated with this process are very similar to those described for inert-gas metal-arc welding.

Allied Processes

In carbon-arc welding, a carbon electrode is used with filler metal added separately, if required. When a shield, either gas or flux, is used, the hazards become similar to those described for inert-gas metal-arc welding.

Gas welding and oxygen cutting on mild steel do not generally produce fumes which are harmful under normal conditions. Some oxides of nitrogen may be produced, but these are of no concern, except in confined areas.

Powder washing is a form of cutting in which iron powder is fed into the flame. The fumes produced mainly contain iron oxide and are not considered harmful under normal conditions. However, the amount of fumes and dust produced is usually much greater than in straight cutting, and complaints of a nuisance condition may arise.

Fluxes containing fluorides are frequently used in welding and in brazing brass, aluminium, or other alloys. In this case the heat of the flame may produce hydrogen fluoride. The concentration of hydrogen fluoride in the fumes is frequently high enough to be irritating, indicating that it is over the maximum allowable concentration (3 ppm). The concentration produced in the general room air will depend on the room size, general ventilation, and the amount of welding or brazing being done. If the flux penetrates the outer skin surface through nicks or cuts, or around the fingernails, it may produce severe irritation. Skin contact should be avoided.

Some brazing alloys may contain cadmium, which is readily volatilized on heating. The brown cadmium fumes so evolved are extremely dangerous, producing severe and even fatal lung damage on short exposure. The maximum allowable concentration for cadmium is 0·1 milligram per cubic metre of air.

Welding on materials containing beryllium may produce an extremely dangerous condition. No such welding should be undertaken without proper clearance, and then only after complete control of fumes has been provided.

Welding on tanks, pipelines, or containers of any sort from which the contents have not been thoroughly removed may introduce a serious hazard by volatilization or decomposition of the residue. This is particularly true where chlorinated hydrocarbons or plating solutions may be involved.

Since the possible harmful effects from welding, cutting, and brazing operations are closely related to the fumes and gases produced, appropriate consideration must be given the matter of controlling the inhalation of such gases and fumes.

Special Respiratory Protection

When standard ventilation requirements cannot, for some reason, be instituted, respiratory protective equipment may be needed. Air-line respiratory or hose masks will give adequate protection from welding fumes. Air-supplied welding helmets are available commercially but have been used very little in industry, because of the annoyance and discomfort involved. Respirators approved for metal fumes will give protection against fumes not more toxic than lead, provided that they are selected, used, and maintained properly. Their general use is not recommended, however, because of the difficulty of being sure that these provisions are carried out. No cartridge or filter respirator will give protection against oxides of nitrogen ; an air-line respirator, hose mask, or gas mask is required. Respiratory protective equipment is seldom required at welding operations. In those few instances where it is required, its use should be mandatory.

Health Maintenance Programmes

Some employers have instituted health maintenance programmes for welders. This preventive medical service usually consists of a good physical examination, supplemented by a urinalysis, tests of vision and hearing, and a chest X-ray. The examination is conducted about once a year and serves to spot siderosis or other lung pathology and any change in vision or hearing. The importance of good vision can be readily appreciated, since it has a direct bearing on quality of work and the welder's ability to keep his helmet away from maximum fume and gas production. The examination may also demonstrate

the interest of management in the health of employees.

Like many other potentially hazardous processes, welding, in its many and varied applications, requires the co-operation of all involved, in order to accomplish an optimum health status. Those who design and build and install the equipment have a big responsibility for the welder's health, as also do the safety supervisor, the ventilating engineer, and the industrial hygienist. However, the welder himself must also share in good measure the safeguarding of his own health. An important part in learning his trade is the acquisition of a wholesome respect for the potential hazards involved. Unless a welder understands exactly why each and every safeguard has been afforded him, he is not apt to take his own protection seriously. Unless he really appreciates that the gases and fumes may be harmful, he will fail to develop the good habit of viewing his work from the side and away from maximum gas and fume production.

GERMANY

Improvements in Hot-Rolled Grain-Oriented Transformer Sheet

By A. MÜHLINGHAUS. (From *Elektrotechnische Zeitschrift* (*E.T.Z*), Edition A, Vol. 77, No. 20, October 11, 1956, pp. 732–736, 5 illustrations.)

Although cold-rolled sheet has been preferred to hot-rolled sheet in transformer construction, the possibilities of hot-rolled grain-oriented sheet deserve careful examination. The purpose of this article is to compare the relative merits and disadvantages of cold-rolled and hot-rolled sheet, on the basis of data obtained from tests on standard specimens and from investigations of fully assembled transformer cores.

SINCE the beginning of this century, improvements in the magnetic properties of high-grade electric sheet for transformers are evidenced by a reduction in iron losses. Up to about 1936, this improvement was mainly derived from the methods used in manufacturing hot-rolled sheet; by increasing the silicon content to approximately 4·5% and by annealing, the loss factor L_{10} (at 10 kilogauss) was reduced to about 1·0 W/kg, while the L_{15} value (at 15 kilogauss) was improved to 2·5 W/kg.

Small quantities of sheet with an L_{10} factor of 0·9 W/kg were produced in Germany in 1939 but, as a result of the war, commercial production of high-grade sheet was not resumed until 1950, when, to meet the demand, it was necessary to import from the U.S.A. considerable quantities of steels with a loss factor L_{10} of 0·93. The reason for the increasing demand for low-loss sheet is that, in transformers, the iron or no-load losses may constitute an appreciable proportion of the annual losses, if the transformers are operated under no-load or partial-load conditions for a considerable period. In addition, it is desirable to keep the magnetizing force, and hence the no-load or reactive current of the transformer, at a low value, thereby permitting a reduction in the corresponding power losses and reactive power of the generators.

Fundamental research in the U.S.A. in two independent investigations carried out around 1930 showed that, by means of certain rolling and annealing processes, it is possible to produce a cold-rolled sheet material with a maximum silicon content of about 3·2%, with a loss factor L_{10} in the longitudinal direction of less than 0·6 W/kg, and more recently as low as 0·48 W/kg, and with an L_{15}-value of only 1·1 W/kg approximately. Industrial utilization of this research commenced around 1942. Because of the small proportion of this material in the total production of the U.S.A., this grade of sheet was at first used only for single-phase transformers, in which it was preferred for various reasons, i.e., the more suitable shape of the core ; the time saved in manufacture by machine winding of the laminated core ; the very high proportion of single-phase transformers produced in the U.S.A., compared with three-phase transformers ; and the fact that maximum magnetic flux density can be increased to between 15 and 16 kilogauss, instead of the previous value of 13 kilogauss, with a similar reduction in no-load losses. Furthermore, the reduction in no-load current to about 10% of its previous value and the decrease in iron losses for the same flux density were advantages which were regarded as being of decisive importance.

Subsequently, attempts were made to use this sheet in three-phase transformers as well, but, owing to practical considerations, these transformers had to be modified, especially in the case of large-size units. It was then found in the U.S.A. that, even when flux density was increased from 13 to between 15 and 16 kilogauss, at nominal voltage, it was possible to utilize a core of smaller weight, without affecting the reduction in losses obtained, as compared with previous sheet. However, various other properties of cold-rolled sheet or oriented material were also found, and these tended to reduce or even to cancel the advantages achieved.

HOT-ROLLED GRAIN-ORIENTED SHEET FOR TRANSFORMER CORES

Because better-quality hot-rolled sheet was not available at the time, the European electrical industry endeavoured to obtain grain-oriented sheet for three-phase transformers. It was known from American literature that low no-load losses were attainable with such sheet, and it was therefore believed that low no-load losses could be achieved only by its use.

However, in view of the favourable properties of oriented sheet and the known limitations of cold-rolled sheet, it was considered desirable to investigate the possibilities of oriented hot-rolled sheet. Accordingly, non-destructive tests were carried out, involving extensive measurements of electric sheet after manufacture and assembly, so as to obtain data on loss factors with the smallest amount of scatter. At present, it is possible to produce hot-rolled sheet in which the losses of specimens cut in the transverse direction are 40% higher than those in the longitudinal direction. Moreover, sheets of 1 metre in width and up to 3 metres in length have been made. The results of tests on these hot-rolled materials, compared with cold-rolled sheet, are given in Table I. The loss factors of hot-rolled transformer sheet for specimens

cut in the longitudinal or rolling direction (curve (1)), and for composite specimens made up of sheets of which half were cut in the longitudinal and half in the transverse direction (curve (2)) are shown as functions of flux density in Fig. 1. Curves of flux density as a function of magnetizing force for similar specimens, i.e., cut in the longitudinal direction (curve (1)) and composite specimens (curve (2)), are shown in Fig. 2.

Comparative Tests

As a result of operational experience, information has been accumulated on the increased losses occurring with cold-rolled sheet in actual installations. Similar data are lacking for hot-rolled oriented sheet, but it can be expected that the difference between their loss factors and effective no-load losses should be smaller than for cold-rolled sheets, firstly because the ratio of transverse to longitudinal losses is at most only half as high for hot-rolled sheet as for cold-rolled sheet, this being important with regard to core bolts and edge effects, and secondly because the increase in losses caused by mechanical manufacturing processes is much smaller for hot-rolled sheet.

It appears, therefore, that only practical tests can supply this information. If a typical transformer is chosen, it should be possible to test it with, say, four different types of core material, in all cases with the same type of winding and general arrangement. Core No. 1, for instance, can be made up of layers of sheet alternately cut in the longitudinal and transverse directions, with an L_{10}-value of 1·15 W/kg. This composite core can then serve as a reference standard for measurements of no-load losses at nominal voltage and flux density, and also for comparison with measurements in test apparatus with the same flux density. The difference between the results of these two tests will then give the increased loss occurring in the fully assembled condition.

Table I: Comparative Properties of Hot-Rolled and Cold-Rolled Sheet.

	Hot-rolled		Cold-rolled	
	transverse	longitudinal	transverse	longitudinal
Magnetizing force at a flux density of 15 kilogauss [amp.-turns/cm]	33	21	29	0·6
Loss factor L_{10} of Epstein test specimen [W/kg]	1·13	0·81	1·2	0·48
Loss factor L_{10} of fully assembled core [W/cm]	—	0·9	—	0·7
Reduction in no-load current, compared with previous manufacturing method [%]	—	25–30	—	70–90
Ratio of hysteresis losses to eddy-current losses	—	0·7/0·3	—	0·5/0·5
Ratio of loss factors in transverse and longitudinal directions	1·1/1·0		2·5/1·0	
Joint	straight		45°	
Core bolts	can be used with practically no increase in losses		can be used only with increased losses	
Subsequent annealing	not required		required	
Insulation	varnish or paper		high-temperature-resistant	
Mechanical sensitivity	low		very high	

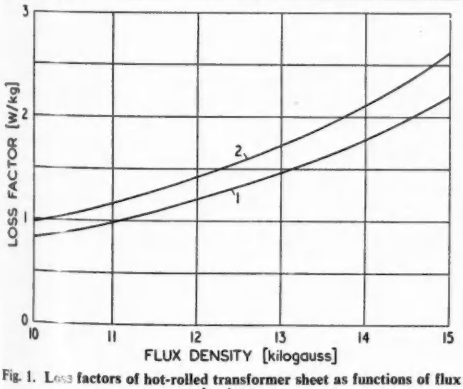

Fig. 1. Loss factors of hot-rolled transformer sheet as functions of flux density.

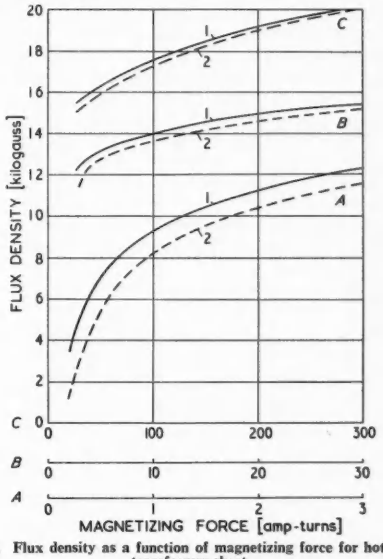

Fig. 2. Flux density as a function of magnetizing force for hot-rolled transformer sheet.
The letters *A*, *B*, and *C* refer to the corresponding scales of the abscissa.

Core No. 2 can be of laminated material cut in the longitudinal direction. If measurements in the longitudinal direction give a loss factor of, say, 0·91 W/kg, i.e., 79% of the L_{10}-value of core No. 1, then in the most favourable case it may be expected that, assuming the loss factors at nominal flux density to be in the same ratio as at 10 kilogauss, the no-load losses of core No. 2 will be smaller by the same percentage, relative to those of core No. 1.

Similarly, cores Nos. 3 and 4 can be made from oriented hot-rolled sheet with loss factors of 0·85 and 0·81 respectively. At best, it may be expected that the losses obtained with the test apparatus will vary in the same way as those measured on the transformer, with a constant percentage difference for all four cases.

It may be noted in this respect that this difference is not constant for cold-rolled transformer sheet; the difference becomes greater for sheet with decreasing loss factors, so that the full benefit of the improvement in the grade of sheet cannot be reached in practice. Moreover, besides the arrangement of sheet cut in the longitudinal direction, it may be mentioned that the 45-deg. joint and subsequent annealing which are associated with the use of oriented cold-rolled sheet entail increased costs, and it is not yet known whether with hot-rolled sheet these treatments have such advantages as to justify this additional expenditure.

There is also a relation between the losses of core

laminations and the additional losses in the transformer tank. If the four cores, for instance, are placed in oil-filled tanks of the same type, their additional losses will be different, since experience indicates that low-loss sheet has a higher magnetic conductivity and therefore smaller stray fields. Hence, losses in the tank will be reduced correspondingly. Furthermore, it will be necessary to carry out tests at various flux densities, in order to take account of possible fluctuations during tests, and to be able to assess the trend of the curves in the results.

Another question to be raised is the quantity of material required for the complete transformer, so as not to exceed the specified no-load losses, as well as its relation to the improvement attainable and to the manufacturing costs. In principle, a minimum no-load loss can also be achieved with sheet having a relatively high loss factor, but the total quantity of material required then becomes greater.

Finally, it is necessary in such tests that the sheets used should be of uniform quality. Whereas previously, individual tests could be made only on Epstein specimens, i.e., on sheets which could then no longer be employed in the assembly, because of unsuitable dimensions, it is now possible to carry out tests with equipment capable of being used with an entire sheet. Careful grading can thus be obtained for all materials used in the transformer cores.

On the basis of the above, a series of comparative tests was carried out, a transformer of 100 kV nominal power being selected, with a nominal voltage of 400 V on the secondary and 10 kV on the primary side, and a relative short-circuit voltage of 3·7%. The test cores were designed so that at nominal voltage they would have a flux density of 14·7 kilogauss through the core and 12·5 kilogauss through the yoke. In estimating the no-load conditions, the core losses of core No. 1 were estimated at about 600 W, while the sum of core and transformer-tank losses amounted to approximately 630 W. Different grades of sheet were used for cores Nos. 2, 3, and 4, but all cores had the same dimensions. Fig. 3 shows loss factor as a function of flux density for cores made from four different grades of sheet, core No. 1 being a composite made up of layers of sheet alternately cut in the longitudinal and transverse directions (curve (1)), and cores Nos. 2, 3, and 4 made up of sheets cut in the longitudinal direction only (curves (2), (3), and (4)).

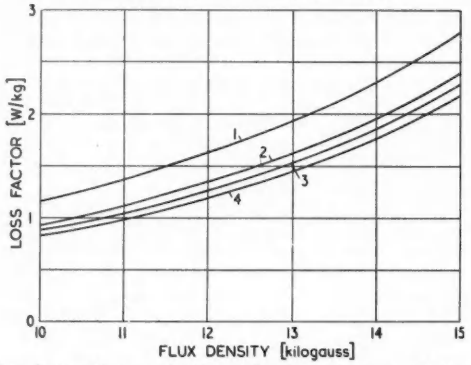

Fig. 3. Loss factors as functions of flux density for cores made from four different grades of sheet.

Comparative results of measurements are given in Table II, in which L_{10} and L_{15} are the respective loss-factors of Epstein specimens at 10 and 15 kilogauss [W/kg], P_{NL} and $P_{NL(1)}$ are respectively no-load power and the no-load power of core No. 1 at 14·7 kilogauss [W] I_{NL} and $I_{NL(1)}$ are respectively no-load current and the no-load current [A] of core No. 1, subscripts a and b refer respectively to cores with sheet cut in the longitudinal direction and to composite cores, as indicated above, and $L_{15c}/L_{15(1)}$ is the ratio of the loss factors at 15 kilogauss of a core in the fully assembled condition to that of core No. 1.

Table II : Comparative Results for Four Different Grades of Sheet.

	Transformer Core No.			
	1	2	3	4
L_{13b}	1·15	1·04	0·98	0·97
L_{15b}	2·80	2·70	2·60	2·58
L_{15b}/L_{13b}	2·44	2·60	2·66	2·66
L_{13a}	1·02	0·91	0·85	0·81
L_{15a}	2·54	2·38	2·26	2·16
L_{15a}/L_{13a}	2·49	2·62	2·66	2·66
L_{15b}/L_{15b}	0·91	0·88	0·87	0·84
$L_{15c}/L_{15(1)}$	1·00	0·85	0·81	0·77
P_{NL}	595	510	470	455
$P_{NL}/P_{NL(1)}$	1·00	0·86	0·79	0·76
I_{NL}	8·81	7·90	6·90	6·50
$I_{NL}/I_{NL(1)}$	1·00	0·84	0·78	0·74

It will be noted from Table II that there is good agreement between the loss-factor ratios $L_{15c}/L_{15(1)}$ and the corresponding no-load power ratios $P_{NL}/P_{NL(1)}$. Since only relative values are of importance in this comparison, grade selection must be based strictly on the loss factor.

From the results of this first series of tests, the following conclusions can be derived :—

(1) Electric steels with unidirectional properties for transformers can be manufactured by hot rolling.

(2) This orientation in the longitudinal or rolling direction shows a loss reduction of about 20%, as compared with the value for the hitherto usual Epstein specimen of the composite type ; a further improvement in texture appears possible, with a further reduction of losses in the rolling direction.

(3) The basically higher silicon content of hot-rolled transformer sheet, as compared with cold-rolled sheet, results in a lower percentage of eddy-current losses for the same thickness of sheet.

(4) It seems likely that it will be possible to reduce further the at present unfavourable loss-factor ratios L_{15}/L_{10}, so that the prospect exists of decreasing the difference in L_{15} values between hot-rolled and cold-rolled transformer sheet.

(5) With the use of hot-rolled oriented sheet in transformer construction, there is the possibility that the low loss factors in the rolling direction will have their full effect on the no-load losses of the transformer core.

(6) In addition to power losses, the no-load current and the reactive power are also decreased.

(7) The advantages of the texture of hot-rolled sheet in transformer manufacture can be obtained even without special shaping procedures at points of flux deflection and without subsequent annealing treatment.

(8) In principle, therefore, it is possible to achieve lower no-load losses in transformers by means of high-grade hot-rolled sheet. It is a matter of economics to decide to what extent it is more appropriate to use low-loss sheet or to reduce flux by using a greater quantity of material.

The Principle of "Convergence-Divergence" as a Basis for Quantitative and Qualitative Mixing

By Dr. M. S. Frenkel*

In our November issue, the principle of Convergence-Divergence was discussed in connection with mixing and other applications, particularly with regard to their derivation from three basic mixer constructions. Ideal considerations indicate, however, that both quantitative and qualitative mixing should be used, and in this article the C-D principle is applied to distinguishing the fundamental requirements of quantitative and qualitative mixing and to describing equipment designed to combine both these kinds of mixing in practice.

In considering quantitative and qualitative mixing on the basis of the principle of "Convergence-Divergence" (*C-D*), these two kinds of mixing may be considered complementary, having convergence in that quantitatively they have the same required ratio, e.g., by weight, between the constituent media, and that they have divergence in that a quantitative mixture has only this quantitative ratio between the media, while a qualitative mixture has in addition a qualitative relationship.

A purely quantitative mixture, e.g., of dry powders, is far from representing the required degree of mixing throughout the majority of positions in the mixture, inasmuch as, generally, it merely represents, in different positions, degrees of intermixing varying between widely divergent maximum and minimum values, as has been fully confirmed by recent experimental measurements. On the other hand, a mixture which is both quantitative and qualitative, in accordance with the *C-D* principle, represents the same degree of intermixing throughout the majority of positions in the mix.

Consider first the simplest case of two dry powders *A* and *B*, of equal specific gravity and particle size, which are to be intermixed in the weight ratio $G_B/G_A = n$. On the basis of a quantitative criterion, this means that every particle of material *A* of a certain weight should be combined with *n* particles of material *B*, each of the same weight. However, in this combination, the relative disposition of each particle of material *A* in the *n* particles of material *B* can be entirely different, even if the combination, as such, could be achieved.

For example, suppose that, out of the infinite number of relative positions possible in such a combination, each particle of material *A* is located at the centre of a sphere, the volume of which is filled by the *n* particles of material *B* at different radial distances from the single particle of *A*. The local degree of quality of the mixture depends on the radial distances of the various particles of *B* from the central particle of material *A*, and the result is therefore a differing degree of quality, ranging from a maximum for particles of *B* adjoining the single central particle of *A*, to a minimum for those particles of *B* which are at the periphery of the sphere surrounding the particle of *A*.

Consequently, it will be appreciated that, even if it were possible to achieve a mixture which is in proportion quantitatively, the quality of the mixture still varies inherently by widely divergent degrees, the difference between maximum and minimum being possibly very great, depending on the required proportion *n*. Hence, this case, which already assumes a uniform distribution, does not correspond with qualitative requirements.

In order to obtain the required quality of mix throughout, one method would be to split each particle of material *A* into *n* fragments (where *n*, as above, is the required intermixing ratio by weight), so that each particle of *A* will no longer have the same weight as that of a particle of *B*, but $1/n$-th thereof. In this case, distribution can be effected by suitable equipment in such a way that substantially every particle of material *B* is associated with a particle of material *A* having $1/n$-th of the weight of the particle of *B*. Other numerical combinations of particles of *A* with particles of *B* are, of course, possible.

Now, assume equal particle sizes, a required weight ratio $G_B/G_A = n$, and specific weights of materials *A* and *B* in the ratio $\gamma_B/\gamma_A = s < n$. Then, on a purely quantitative basis, one particle of *A* would be combined with n/s particles of *B*. Here again, even assuming the special case of distribution in which each particle of *A* is surrounded by a sphere containing n/s particles of *B*, the degree of intermixing will be widely divergent, depending on the relative values of *n* and *s*.

In order to obtain the required quality of mix through-

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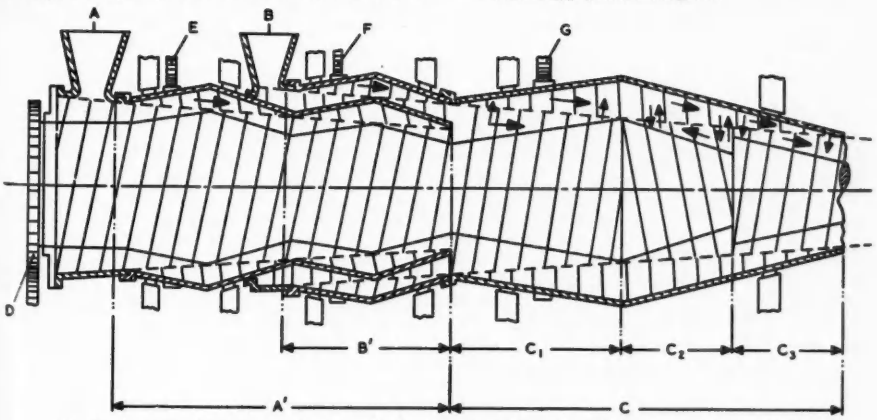

Fig. 1. Diagrammatic arrangement of a multi-mixer for quantitative and qualitative mixing of two materials.

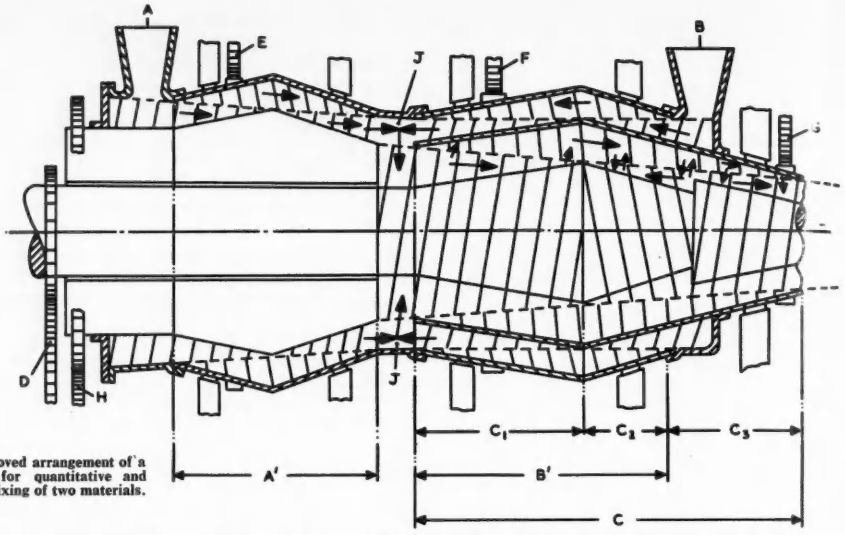

Fig. 2. Improved arrangement of a multi-mixer for quantitative and qualitative mixing of two materials.

out, one method out of many would be to split each particle of *A* into *n*/*s* fragments. It would therefore be possible with suitable equipment to combine each particle of *B* (weighing *s* units) with a particle of *A* (weighing *s*/*n* units), thus providing a qualitative criterion, in addition to a quantitative criterion.

These considerations show that, for a qualitative mixture, it is necessary to obtain corresponding ratios of particle weights, i.e., particle sizes, and this requires that the materials concerned should be subjected to different treatments before they are actually intermixed.

In general, conventional mixing equipment suffers from the drawback that only quantitative mixing is attempted. On the other hand, ideal mixing necessitates a combination of both quantitative and qualitative mixing. A continuous mechanical method of combining these two kinds of mixing is the multi-mixer shown diagrammatically in Fig. 1, the construction of which embodies basic constructions I and III described in a previous paper†, construction I relating to the milling cycles of two materials, and construction III to the mixing cycle.

Material *A*, which is to be reduced to a smaller particle size, passes through the two internal milling cycles A′, while material *B* is subjected to the external milling cycle B′, the two materials being then combined in the mixing cycle *C*. The speed of rotation of the inner screw is controlled by drive *D*, while those of the outer and intermediate screws are controlled by drives *E*, *F*, and *G*. The particle size produced in the milling cycles depends (a) on the number of turns between entry and exit, the number of turns per cycle, and the number of cycles, these being design variables ; (b) on the clearance between the screws, this clearance being easily adjustable ; and (c) on adjustment of the relative rotational speeds of the inner- and outer-screw components. By virtue of this feature of adjustability, the particle sizes of materials *A* and *B* can be varied, as required, quite independently of one another, in only one machine.

This machine, in accordance with the *C-D* principle, produces two complementary kinds of mixture, i.e., quantitative and and qualitative. Other combinations of multi-mixer can, of course, be arranged, as dictated by the properties and other requirements of the materials to be intermixed. In addition, multi-mixers can be constructed on the same principle for intermixing three or more materials.

An improved arrangement is illustrated schematically in Fig. 2, in which the milling cycle *A′* (with its outer drive *E* and inner drive *H*) and the milling cycle *B′* (with its outer drive *F* and inner drive *G*) drive materials *A* and *B* in opposite directions, bringing them into the required qualitative condition and, at the same time, by adjustment of relative speeds, acting as metering devices for the quantitative combination. The materials are first mixed by interpenetration in the mixing chamber *J*, mixing being effected, apart from the vortices produced by the screws of milling cycles *A′* and *B′*, by impact in three mutually perpendicularly directions, i.e., opposite velocities in the axial direction, opposite velocities in the circumferential direction, and different velocities in the radial direction. As before, drive *D* controls rotation of the inner screw. From chamber *J*, the materials enter the internal mixing cycle *C*, formed between the innermost and outermost components. In this construction, axial thrusts on the components involved are reduced, owing to the opposite drive direction of the materials.

With regard to the mixing cycle *C* in Figs. 1 and 2, representing basic construction III, strict consideration of this cycle, which can be considered as made up of part-sectors C_1, C_2, and C_3, leads to the possibility of a further modification, which may be called basic construction IV. In this connection, convergence with the sector formed by part-sectors C_2 and C_3 should require that part-sector C_1 should also have a part-sector with simultaneous material transfer; as a result, a part of sector C_1 should have a reversed screw, as in part-sector C_2, and divergence with the sector composed of part-sectors C_2 and C_3 would require that this reversed screw should be the outer component.

In general, in order to reduce axial thrust on any mixers constructed on the *C-D* principle, the outer surfaces of external rotating components can be formed as transport screws driving in a direction opposite to that of transport within the mixer, these outer screws operating in a stationary housing.

† "The Principle of ' Convergence-Divergence ' in Mixing and Other Applications." *The Engineers' Digest*, November 1956, pp. 475–480.

Research on the "Multiwhistle" Acoustic Air-Jet Generator

By R. M. G. Boucher and E. Brun. (Based on a paper read by R. M. G. Boucher at the Second International Congress on Acoustics, Cambridge, U.S.A., June 1956.)

The purpose of the study described in this paper is to determine systematically the interrelation between the acoustic features of emissions produced by ultrasonic air-jet generators and the aerodynamic and mechanical factors controlling their operation. In addition to a short survey of some new facts disclosed by the authors' research and the most important theoretical conclusions derived therefrom, a new industrial air-jet generator is described, together with indications of some of the promising results obtained in practical applications, particularly in the fields of industrial drying and fog dissipation.

Research by the authors on the design of new types of ultrasonic whistles or sirens was intended to continue the investigations carried out by Hartmann[1], the inventor of the ultrasonic air-jet generator, i.e., a device consisting basically of a nozzle and a resonator of equal aperture located in the so-called "first interval of instability", thereby producing a system of very powerful oscillations. One important difference between the experimental whistles originally designed by Hartmann and those designed by the authors was the greater relative resonator aperture of the latter. While Hartmann's whistles had a coefficent K (ratio of resonator aperture to nozzle aperture) equal to unity, the authors consistently used values of K ranging from 1·33 to 2·5. Values of K greater than 1·3 appear to be better suited to the particular structure of ultrasonic air jets, so much so that it was found possible virtually to double the efficiency of Hartmann generators.

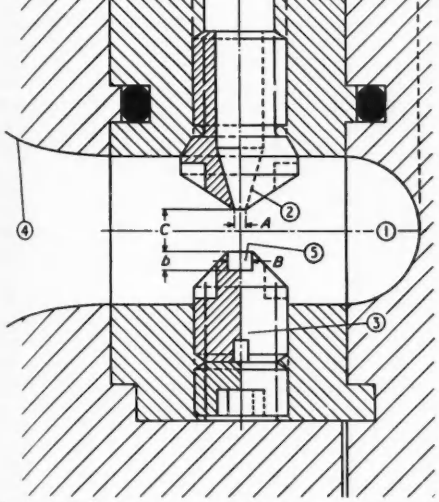

Fig. 1. Schematic drawing of a whistle with a secondary resonance chamber.

Another difference lies in the fact that Hartmann's whistles were symmetrical with respect to the jet axis, whereas the authors' whistles were surrounded by a secondary resonance chamber (1), as shown in Fig. 1, the nozzle (2) and resonator (3) being located between this chamber and the exponential horn (4). Four types of whistle were studied, these differing in respect of nozzle aperture A, aperture B and depth b of the primary resonance chamber (5) of the resonator, and the distance between the nozzle and resonator apertures C, as shown in Table I.

Table I: Types of Whistles

Dimensions [mm]	TYPE OF WHISTLE STUDIED			
	G	A'	V_I	V_{II}
A	1·5	1·5	4·5	1·8
B	2·0	2·0	7·25	4·5
C	1·97	2·35	9·0	3·25
b	1·9	5·0	6·5	5·0
$K = B/A$	1·33	1·33	1·61	2·5

From the point of view of the power rating of whistles, the shape of the secondary resonance chamber (1) proved to have a very marked effect, by no means assignable merely to the phenomenon of reflection. As a matter of fact, differences of over 10 db were recorded for a type-G whistle tested with differently shaped resonance chambers, as shown in Fig. 2, with a constant distance C between the apertures of the nozzle and the resonator.

In addition, checks were made regarding Hartmann's observations on the intervals of instability, i.e., the "pile-up" portions of the total pressure curve. In this connection, Hartmann stated that, with increasing pressure, the thresholds of these intervals were shifted further from the nozzle, while the intervals themselves became longer.

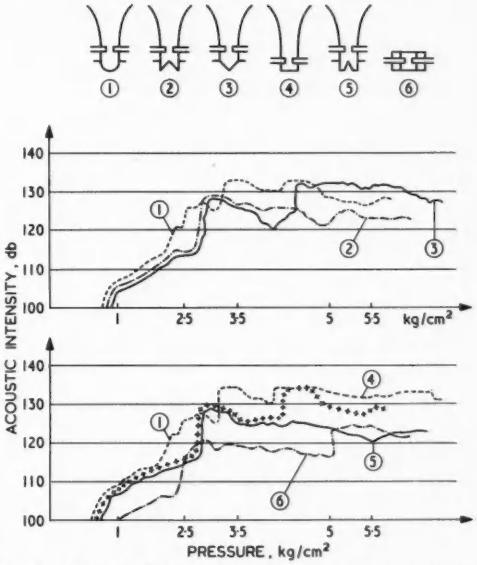

Fig. 2. Influence of the shape of the secondary resonance chamber on acoustic intensity at different pressures.
(1) Hemispherical base.
(2) Base with inward cone.
(3) Base with outward cone.
(4) Flat base.
(5) Base with dihedron.
(6) Whistle in supporting ring, without secondary resonance chamber.

However, on continuing his experiments, it was discovered that too great an increase in pressure sometimes brings the entrance of the first instability interval too close to the resonator, thus causing a sudden drop in the intensity of acoustic emission. This largely accounts for the poor results obtained in industrial practice by a number of experimenters who had expected the efficiency of their generators to rise with increased pressure.

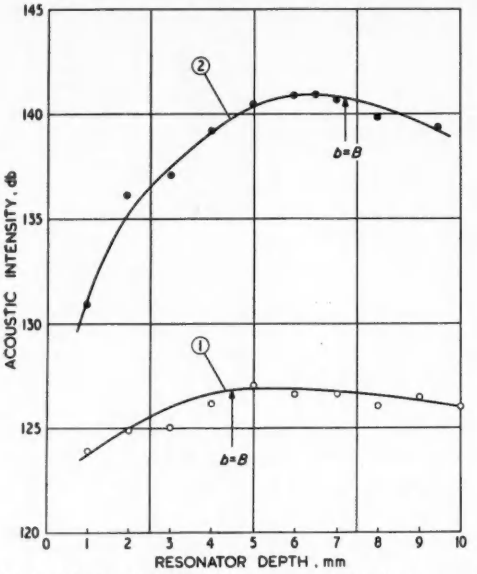

Fig. 3. Influence of resonator depth b on acoustic intensity (measured at a distance of 25 cm from source) of a V_{II}-type whistle at a pressure of 1·5 kg/cm² (curve (1)), and a V_I-type whistle at a pressure of 4 kg/cm² (curve (2)).

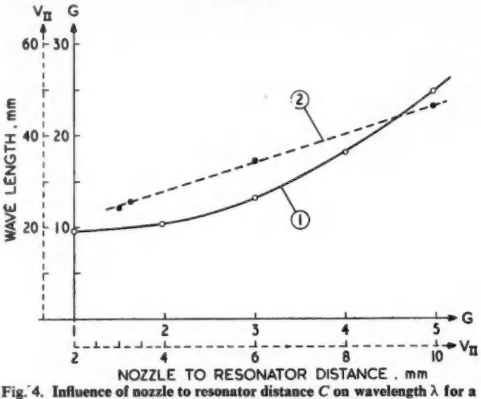

Fig. 4. Influence of nozzle to resonator distance C on wavelength λ for a G-type whistle at 2·5 kg/cm² (curve (1)), and for a V_{II}-type whistle at 5·5 kg/cm² (curve (2)).

The influence of the depth b of the primary resonance chamber of the resonator on the intensity of acoustic emission was also carefully studied. Fig. 3 shows the results obtained for different values of b in a V_I-type whistle at 4 kg/cm² and a V_{II}-type whistle at 1·5 kg/cm². While, as already stated by Hartmann, the influence of resonator depth b does not appear to be of primary importance at low pressures, i.e., in the sonic range, it is of great importance in the ultrasonic range.

Fig. 4 shows wavelength λ as a function of the distance C between nozzle and resonator for a G-type whistle at 2·5 kg/cm² and a V_{II}-type whistle at 5·5 kg/cm². These results, in conjunction with similar plots of intensity of acoustic emission against distance C, have led to the conclusion that each distance x between the wave marking the entrance of the instability interval and the resonator (Fig. 5) corresponds to an acoustic emission of definite frequency, this frequency being a decreasing function of x. On this basis, it seems more logical to characterize emissions with respect to x than, as is customary, with respect to the distance C between nozzle and resonator. This statement is of great importance, inasmuch as it provides a means of predicting exactly the frequency for any whistle operating within the limits of the interval of instability.

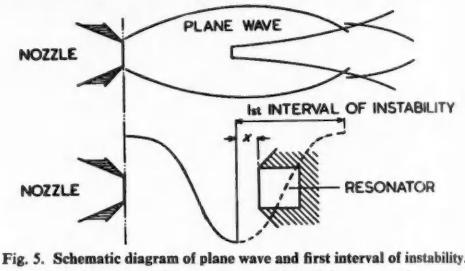

Fig. 5. Schematic diagram of plane wave and first interval of instability.

With regard to the measurement of the acoustic power of the generators, this might be achieved by measuring the pressure exerted by the radiation on an obstacle located in the acoustic field, as suggested by Gavreau and Canac[2]; however, the method finally adopted by the authors was that of Hartmann, consisting of tracing complete radiation patterns around the generator and then integrating (from any pair of curves) the total radiation. Fig. 6 is a typical radiation pattern of this kind for a G-type whistle, at a frequency of 32 kcs and a pressure of 2·8 kg/cm² with an air output of 1·2 gm/sec.

From an examination of more than twenty radiation patterns, it is concluded that there are three main classes of acoustic whistle. The first covers whistles operating within the interval of instability at low pressures (up to

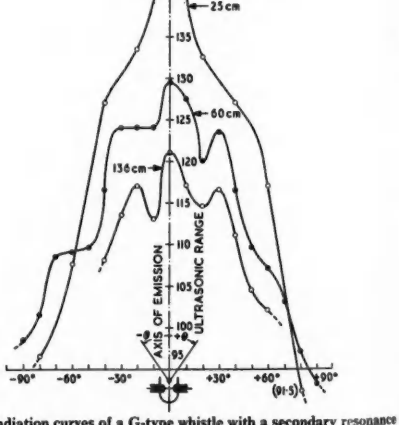

Fig. 6. Radiation curves of a G-type whistle with a secondary resonance chamber.

3 kg/cm²), their efficiency being between 10 and 20%. The second class comprises whistles set for the interval of instability but operating at higher pressures, efficiency being between 5 and 10%. The third class consists of considerably less efficient whistles working outside the interval of instability, or where the interval of instability appears only with high air outputs, e.g., above 7 gm/sec.

Finally, tests were made by the authors to determine the ratio of the coefficient of attenuation of sound α to the theoretical value α_{th} given by Rayleigh's equation, i.e., $\alpha_{th} = 2\pi^2\nu/3\lambda^2 a$, where λ = wavelength, ν = kinematic viscosity of air, and a = speed of sound. These tests confirmed that $\alpha/\alpha_{th} = 5$, as previously noted by Hartmann. Higher values were recorded in the case of complex emissions, but these are easily explainable by the modern theory of sound absorption.

New Design of Industrial Acoustic Generator

As the power capacity of a single whistle is limited to about 150 W, one of the authors (Boucher) has designed a more powerful apparatus for industrial purposes by combining several whistles. As there are no moving parts, this new generator, designated the "R.B. Multiwhistle" (after the initials of the author), may be described as a "static" or "fixed-jet" siren. As shown in Figs. 7 and 8, it is basically made up of a stainless-steel ring (4) to which several whistles are attached, compressed air being supplied centrally through an inlet (1) to the nozzles via perforations in a vessel seated in the body of the generator. Waves emitted by each of the systems of nozzle (6) and resonator (5) are maintained and reinforced in a secondary resonance chamber (7), and are then rectified by means of an exponential horn radiator (2) with a central conoidal shell (3). The whole apparatus is a solid of revolution, designed to provide for a plurality of superimposed rings or rows of whistles.

The main advantages of this patented generator may be summed up as follows :—

(1) While the power of a single whistle (including generators in the form of solids of revolution generated by rotation of a Hartmann whistle, e.g., the "disc-jet" generator of Hartmann and Trudso[3]), is inversely proportional to frequency, the Multiwhistle can supply any acoustic power desired, irrespective of the frequency of emission, merely by increasing the number of whistles secured to the ring or rings. Such a high performance is not readily attainable with other types of generator, not even with dynamic (rotary) sirens, one reason being that the speed of rotation of such sirens[4] is generally limited to 20,000 rpm. Furthermore, the number of peripheral ports controlling the emission frequency is limited by considerations of tensile strength. In the new static siren, however, there are no moving parts, while all nozzles and resonators can not only be easily removed but can also be regulated during actual operation from the exterior, without any need for dismantling the apparatus.

(2) Complex emissions can, if desired, be produced by securing different models of whistle to the ring, and this may prove very useful in aerosol and fog processing. The orthokinetic agglomeration theory of Brandt and Hiedemann[5] has shown that, for every particle size, there is a very definite processing frequency corresponding to the optimum relative displacement between the particles and the gas. Thus, for example, with a displacement ratio of, say, 0·5, a frequency of 2 kcs will be required for droplets of 7 microns, or 50 kcs for droplets of 1·5 microns.

Consequently, in order to obtain the greatest number of collisions, a reasonably wide acoustic spectrum is of more use than a very pure emission and, when processing an aerosol of very uniform particle-size distribution, it is worthwhile introducing different frequency bands, so as to meet the requirements of particles enlarged during the initial stage.

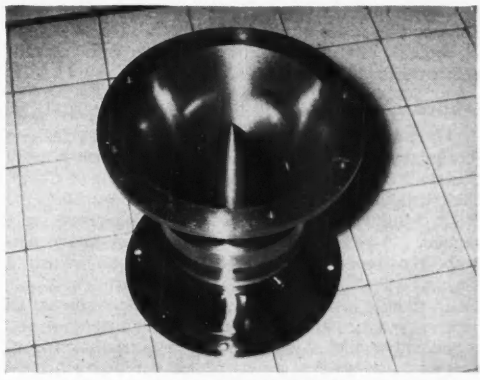

Fig. 7. View of a typical Multiwhistle.

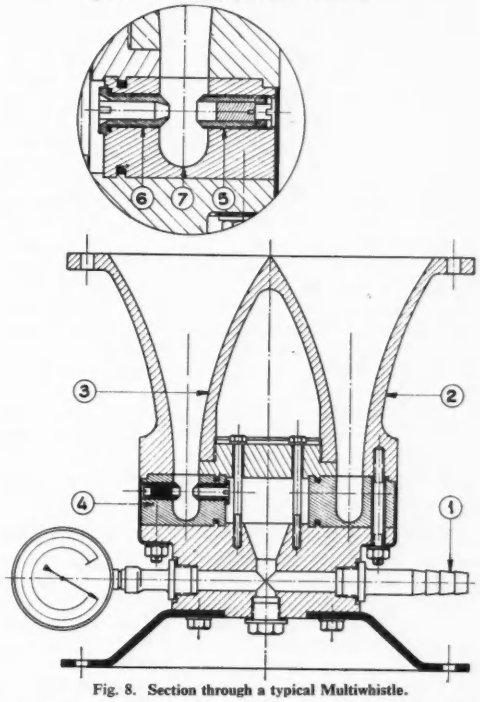

Fig. 8. Section through a typical Multiwhistle.

The Multiwhistle permits the production of complex frequency spectra either by varying the gaseous output, by changing the distance C between nozzle and resonator, or by combining various types of nozzles and resonators. Synchronization is easily achieved for whistles which face in diametrically opposite directions[3].

The ratio of acoustic power actually delivered to consumption of compressed air has been found to be fairly reasonable. Thus, at a fundamental frequency of 10 to 11 kcs and at a pressure of 3·6 kg/cm², the consumption of free air (at NTP) recorded in the industrial processing of

aerosols with the Multiwhistle was 85 m^3/hr with an available acoustic power of 400 to 600 W ; at 32 to 34 kcs and 2·8 kg/cm^2, air consumption was 40 m^3/hr with an available acoustic power of 400 to 500 W.

Commercial Applications of the " Multiwhistle "

Quite apart from the classical problem of gas cleaning (coagulation of fumes and industrial aerosols), already dealt with by numerous investigators, including St. Clair[6], Söderberg[7], Danser and Newmann[8], and Sinclair[9], the R. B. Multiwhistle has yielded interesting results in a number of applications, particularly in connection with the recently developed method of industrial drying.

In terms of industrial practice, " drying " denotes all processing aimed at expelling liquid from a material, and is generally achieved either by heat, e.g., radiation, convection, or high frequency, or by purely mechanical means, such as centrifugation or compression. The use of acoustic waves, particularly air waves in the ultrasonic range, is quite a new feature in this field.

It is well known that the rate of evaporation at the boundary of a liquid-gas interface is primarily controlled by the difference $\Delta P = P - p$, where P is the saturation vapour pressure at the temperature of the liquid, and p is the vapour pressure in the surrounding atmosphere. Since acoustic waves imply a succession of compression and expansion regions, ΔP varies to a considerable extent at different points in the medium. It is also known by experience that the effect of expansion always predominates over that of compression and, as a result, moisture is continuously released, either as a liquid or as vapour. This method appears to have been applied for the first time in 1955 by Gregus and Mirkovics in Hungary ; by using dynamic sirens emitting at 25 kcs for the processing of textile fibres, the efficiencies obtained in this case were reported to be ten times higher than those obtained by standard methods of vapour drying.

It may be said that liquid is mechanically eliminated in much the same way as from a sponge subjected to a series of alternating pressures, the intensity of pressure bearing some analogy with the pressure amplitude of the acoustic wave, and the rate of compression with the vibration frequency. Since, according to Dognon[10], with constant acoustic power the pressure amplitude, i.e., the most important factor, is independent of frequency, sirens of similar power capacity should produce similar effects, irrespective of whether they are emitting at, say, 10 or 33 kcs. This has been confirmed by the authors' tests, although there appears to be a lower limit of frequency below which the inertia of the liquid no longer contributes to desorption. Experiments indicate that this lower limit is about 9 kcs.

It was also found that the heat generated in the material during processing is practically negligible, the temperature increase being of the order of 1°C. This is of interest where the products to be dried are heat-sensitive, e.g., some resins, pharmaceutical powders, and foodstuffs. Incidentally, comparative tests on a number of materials subjected to acoustic drying and to air flow only from the generator, without acoustic emission, have established that the effect on the drying process of the air current discharged by the Multiwhistle is negligible, this air current serving merely to accelerate the elimination of vapour after desorption.

At the moment, investigations in the field of acoustic drying have been limited to a few kilograms of processed products, but the results are definitely promising.

Another application of the R.B. Multiwhistle lies in the acceleration of coagulation of natural fog on airfield runways. A special French Air Ministry publication is to be devoted to this problem, but at this stage it may be mentioned that Multiwhistles fitted with G- and V_1-type whistles achieved complete dissipation of artificial fog in an experimental chamber of 2650 m^3. Processing efficiency seems to be dependent essentially on the type of fog exposed to the acoustic field. Thus, a Multiwhistle generator emitting at 33 kcs, with an acoustic intensity of 138 db, an air consumption of 36 m^3/hr, and a pressure of 2·8 kg/cm^2, succeeded in dissipating entirely within 15 min a dense but finely dispersed fog with an average particle size of about 1 micron and a concentration of more than 1 gm/m^3, whereas the same generator had little effect on a fog with a larger particle size (about 5 microns). This confirms both the theoretical conclusions of Brandt and Hiedemann[5] and the observations previously made by La Mer and Sinclair[11].

Finally, generators of the Multiwhistle type may be adapted for testing the influence of the acoustic field on combustion processes, while a further application may be that of accelerating degreasing in liquid baths. In this connection, the ultrasonic beam emitted by a 350-W Multiwhistle has sufficient intensity to bring about violent agitation and degassing at the surface of a high-viscosity liquid, such as engine oil.

Conclusions

As a result of these investigations, it is concluded that the type of acoustic emission produced by a given nozzle-resonator system of the type described is very closely dependent on the structure of ultrasonic air jets. In particular, the position of the front of the plane wave with respect to the resonator seems to be of primary importance insofar as the frequency of emission is concerned. It would also appear that the coefficient K of resonator to nozzle aperture ratio should be higher than 1·3 if high efficiencies (10 to 20%) are to be attained.

Finally, it is established that the use of a resonator with a secondary resonance chamber, as fitted to R.B. Multiwhistle industrial generators, can result in a considerable increase in power. The Multiwhistle, the basic characteristic of which is that frequency does not depend on power, has given promising results in acoustic drying processes and in the dissipation of fog.

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The Even Distribution of Air Emerging at Right Angles from a Duct

By C. CAILLE. (From *Sulzer Technical Review*, No. 1, 1956, pp. 28–32, 10 illustrations.)

The initial adjustment of the duct outlets of air conditioning installations is often a difficult and lengthy procedure. However, as described in this article, air outlets have been developed which, based on a special phenomenon of aerodynamics, can be adjusted in advance and ensure uniform and draught-free distribution of air.

THE air conditioning of factories is to-day becoming more and more common, especially in the textile industry. Often, the halls or shops concerned are large, so that air may have to flow through more than 100 yards of distribution ducting. It then becomes a problem to expel this air evenly over the whole length of the ducts.

The usual method consists of the use of standardized air outlets with interceptors which project into the duct and divert the air to the outlet grille, a flap or damper being used to regulate the flow of air. If undesirable draughts are to be prevented, the velocity of the air at the grille must be lower than in the duct, and the cross-section of the grille is therefore several times larger than that of the interceptor inlet. When the numerous outlets are located on both sides of the duct, regulation is particularly difficult, and approximately equal flows for all the grilles can be obtained only by a laborious process of trial and error.

It would thus be an advantage if air outlets could be designed which could be adjusted in advance to ensure a uniform outflow of air over the whole length of the duct. Furthermore, it would be desirable to eliminate the usual interceptors projecting into the duct, as they cause considerable resistance to air flow and produce turbulence which may lead to vibration of the thin metal sheeting normally used for forming the duct walls. Finally, as the numerous air outlets of orthodox design represent an appreciable proportion of the total cost of the plant, it would be advantageous to simplify them, in addition to improving their performance.

The solution found by Sulzer Brothers to this problem exploits a phenomenon of aerodynamics known as the Coanda effect (Fig. 1), in which a sheet of air issuing from a jet and flowing along a wall adheres to the wall, even when it is convex and when centrifugal force tends to lift it away. This effect depends on the maintenance of certain proportions between the width and thickness of the sheet of air and the curvature of the wall. A thick sheet, for instance, will not follow a wall with a small radius of curvature.

Fig. 2 explains why the air clings to the wall. In the absence of walls F_1 and F_2, a jet of air emerging from nozzle D takes the course indicated by the broken lines and entrains, by mixing with the surrounding air, the same amount of outside air on both sides. In the presence of the walls, this air suction is prevented on one side and the low pressure thus pulls the jet towards wall F_2.

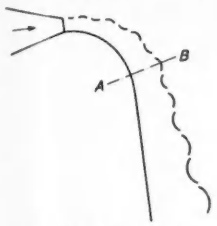

Fig. 1. The Coanda effect.

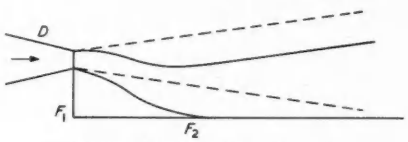

Fig. 2. Sheet of air clinging to a wall.

A jet or sheet of air blown into stationary surrounding air mixes with the latter in accordance with certain known laws. In the case of a sheet of air flowing over a convex wall, the turbulent mixing is intensified by an additional phenomenon which might be termed excess turbulence due to centrifugal instability. Fig. 3, which shows section *A–B* of the sheet of air in Fig. 1, illustrates what happens: When emerging from the nozzle. the sheet of air is smooth and its thickness constant. Turbulent friction with the outside air then produces irregularities which increase with increasing distance from the nozzle and are represented in Fig. 3 as a wavy line. If cross-sections *a* and *b* and the flow of air through them are considered, it can be seen that they are acted upon by centrifugal forces C_1 and C_2 which tend to displace the bounding lines of both cross-sections, as indicated by the dotted lines. C_2 is greater than C_1 and, as the conditions are unstable, the thicker section captures some of the medium of the thinner section. This increases the surface of contact between the surrounding air and the sheet, producing high velocity gradients and longitudinal vortices, both of which cause violent turbulence and thus accelerate the mixing process.

Fig. 3. Centrifugal instability.

The results of laboratory measurements made to elucidate the process by which a sheet of air mixes with the surrounding air are illustrated in Figs. 4, 5, and 6.

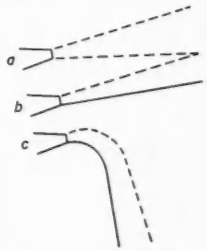

Fig. 4. Different flow conditions used in laboratory measurements.

In Fig. 4, *a* is a completely free sheet of air which mixes with the surrounding air on both sides, while *b* is a sheet of air bounded on one side by a wall, and *c* a sheet of air bounded on one side by a wall which turns through 90 deg. a short distance from the mouth of the nozzle.

Fig. 5 gives examples of overall pressure distributions in the sheet cross-section, as measured with a Pitot tube, for conditions *a*, *b*, and *c* in Fig. 4. In the case of the free sheet *a*, the velocity and dynamic pressure distribution are symmetrical. The static pressure is approximately equal to the barometric pressure, so that the total pressure may be taken as being equal to the dynamic pressure head. In the case of sheets *b* and *c*, the braking effect of the wall is less pronounced than that of the turbulent

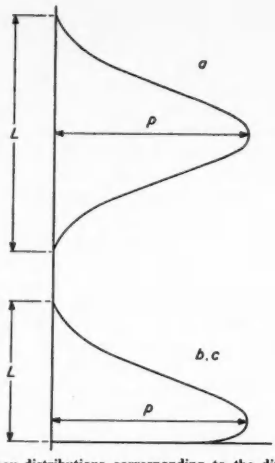

Fig. 5. Energy distributions corresponding to the different flow conditions in Fig. 4.

friction with the surrounding air, so that the zone of maximum velocity lies nearer to the wall.

These distributions were measured in many cross-sections along the sheets of air. For each cross-section the maximum pressure p and the width L of the mixing zone were determined and were plotted in the diagram shown in Fig. 6. The distances of the cross-sections of measurement from the nozzle are plotted along the abscissae as multiples of the width e of the nozzle slot.

The curves L show that the width of the mixing zone is greatest with the free sheet and smallest for a sheet following a wall and mixing on one side only.

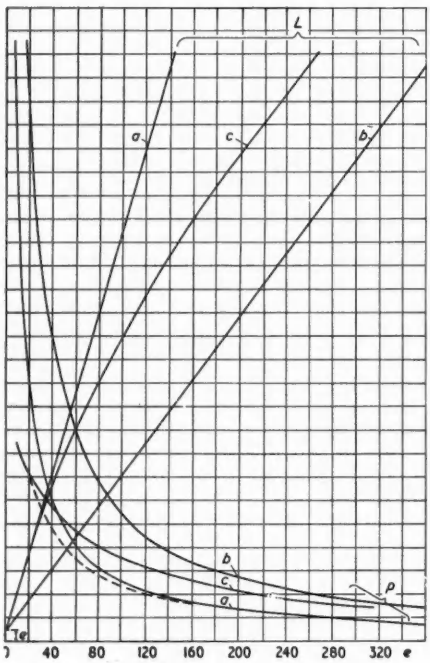

Fig. 6. Evaluation of measured results.

Curve c illustrates convincingly the effect of the excess turbulence produced by the curvature of the wall; up to a distance of 40e (initial thickness of sheet equals nozzle width) the mixing zone is almost as wide as with the free sheet. It should be noted here that the developed length of the curved part of the wall is only 14e. After a time, curve c moves away from curve a, and at 220e it is parallel to curve b. This means that excess turbulence has disappeared and only normal mixing turbulence remains.

Among the curves for the total pressure p, curve b lies highest; in other words, mixing takes place most slowly along the straight wall. The slower the mixing the smaller is the width L of the mixing zone and the higher the pressure p. Over the greater part of its path, curve a is the lowest of the three, and curve c takes an intermediate course, as before. However, over a distance of 46e, c lies below a; in other words, excess turbulence on one side causes more intense mixing than normal turbulence on both sides.

Generally speaking, rapid mixing is desirable in the air outlets of ventilating plant in order to avoid long-range, draught-producing air streams. Rapid mixing can be achieved either by excess turbulence or by using a free sheet of air. In case c it is attained by cutting off the wall just after the curvature, thus suddenly turning the over-turbulent flow into a free jet with maximum mixing on both sides (broken line in diagram).

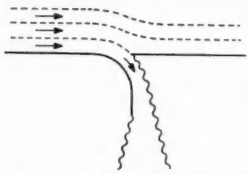

Fig. 7. Slot in a duct wall with curved, projecting tongue.

In applying the above results to practice, Fig. 7 shows how a slot-type nozzle in the wall of a duct would have to be shaped. Although the arrangement differs somewhat from that shown in Fig. 1, the desired effect is obtained with scarcely any losses. In practice these openings take the form of vertical slots in the lateral walls of the ducts, their length being 50 to 90% of the height of the duct, and the distance between them equal to or twice the length of the slots. The width of the slots lies between 1 and 3 cm. The air emerges at the relatively high speed of 10 to 12 metres per second. With rapid mixing this high speed is quite acceptable in a large room, partly on account of the excess turbulence and partly as a result of the cross-sectional form of the sheet of air, which is a long rectangle giving a large surface of contact between the flowing and the surrounding air.

It only remains to be explained why the cross-section of the slots, i.e., their width, can be calculated in advance. The difficulty of distributing the emerging air uniformly over the whole length of the duct is due to the pressure loss in the duct. Actually, in spite of the great length of many air ducts, pressure losses, even with conventional outlets, are usually small. The reason for this is that the velocities are reduced along the duct, since, for the sake of simplicity, constant cross-sections are used over long distances. By making projecting interceptors unnecessary, slots naturally reduce the pressure loss even further. This alone, however, would not permit the slots along the whole length of the duct to be made of the same width, as is done with success in practice. The fact is that the conditions of flow along the slotted inside wall of the duct

are very similar to those over an aircraft wing with continuous boundary-layer control. Just as on an aerofoil, there is no separation of flow along the slotted walls, separation in the duct being restricted to the bounding surfaces without slots. The energy of the medium flowing along the slotted walls thus scarcely decreases along the length of the duct, and for this reason the air can be distributed evenly by slots of constant width.

To illustrate this fact, measurements were made of the overall pressure distribution in an experimental duct of constant cross-section, 10 metres in length, and fitted with 49 slots, each 7 mm in width. It was found that, assuming 100% pressure at the duct inlet, there was virtually no reduction in pressure 5 metres from the inlet, after which the pressure dropped to 98% at 7 metres, 96% at 8 metres, 94% at 9 metres, and 90% at 10 metres, the velocities, and hence the volumes of outflowing air, being reduced to 94·8% with constant slot cross-sections. If even more uniform distribution is desired, the last slots can be made somewhat wider.

From the above, it can be seen how a simple and practical solution to a ventilation problem has been found by having recourse to an aerodynamic phenomenon that is often overlooked and has been little studied from the theoretical standpoint. No doubt the occasions are rare on which a number of factors combine to such favourable effect as in this application. If a sheet of air is to be diverted by the Coanda effect through an angle of 90 deg., it must be thin. If draughts are to be prevented, the air flowing out of the duct openings must mix rapidly with the surrounding air, and this happens precisely with a thin sheet of air. In addition, the excess turbulence which accompanies the Coanda effect greatly promotes the mixing process. The expulsion of the air through slots has the effect of boundary-layer control along the wall of the duct, so that kinetic energy there remains practically constant and the amount of air expelled is kept uniform along the whole length of the duct. Finally, the intense mixing permits high outflow velocities, making for small air-outlet dimensions and consequently for low cost.

GERMANY

The Rolling-Ring Drive for Converting Rotary into Reciprocating Motion

By J. UHING. (From *Konstruktion*, Vol. 8, No. 10, October 1956, pp. 423–428, 14 illustrations.)

To convert rotary into reciprocating motion, various arrangements such as belt drives, rack-and-pinion drives, hydraulic pistons, wheel-and-crank drives, screw spindles, etc., have been devised. These give good results, but for many applications are not entirely satisfactory, particularly when it is required to vary the speed, the stroke, and the force transmitted. Frequently, these conditions can be fulfilled only by means of additional drives, thereby increasing the size of the assembly.

It seemed appropriate, therefore, to try to develop systematically from kinematic principles a drive with simple features and good efficiency which would convert rotary into reciprocating motion while permitting stroke length, speed, and power to be adjusted independently. Also, although the theoretical aspects might be somewhat more intricate, it was considered logical to investigate the possibilities of three-dimensional systems in which the planes of the driving and driven members are at right angles to one another.

In addition to the mechanisms mentioned above, there are also some special types of friction drives which are used, for instance, in winding machines and computing devices. A well-known arrangement of this type, which operates in the same way as a screw spindle, is shown in Fig. 1. Basically, it consists of a rotating plain shaft in contact with a friction roller. By means of a spring load, the roller (*a*) is pressed with a force *P* on the rotating shaft (*b*) and is thus caused to rotate about its horizontal axis. The roller is mounted in a pivotable yoke or frame, with a vertical axis (*c*), of which the centre line passes through the point of contact of the shaft and roller.

By means of a carriage sliding on a horizontal guide, the friction roller and its yoke can move in either direction parallel to the shaft. Now, if the roller is set at an angle β relative to the shaft, and the shaft has a peripheral velocity v_b, the roller will rotate about its own axis with a peripheral velocity v_a. Moreover, the roller will also have a velocity in the axial direction of the shaft. If N is the shaft speed [rpm] and D the shaft diameter, from the triangle of velocities in Fig. 1 it can be shown that this resultant velocity component v_r is

$$v_r = ND\pi \tan\beta$$

Thus, when the shaft speed is constant, the roller and its carriage perform a traversing motion which depends only on the pivot angle β. By altering this angle, therefore, it is possible to change the absolute value of velocity and also to reverse the direction of motion. Since there is only pure rolling without sliding at the contact point, the amount of wear is extremely small. Because of these

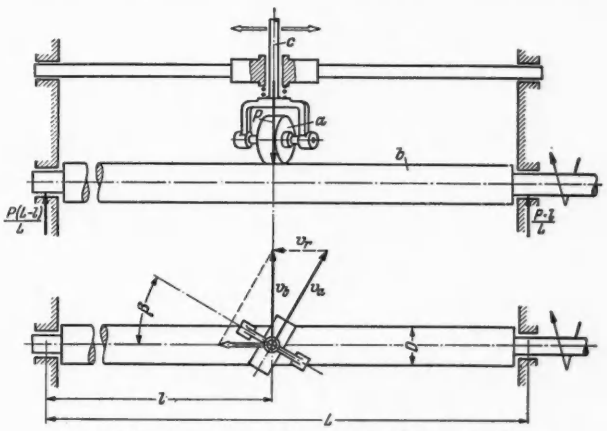

Fig. 1. Schematic arrangement of a conventional friction-roller drive.

attractively simple features, this arrangement has been employed for many purposes, although, in relation to the size of the assembly, the force transmitted in the direction of the traversing motion is not very great. The reason for this is that the point contact between roller and shaft permits only low specific pressures. The transverse force can be increased considerably by using several rollers distributed around the shaft periphery, and this also permits an appreciable reduction in undesirable pressures in the bearings of the shaft. However, the use of several rollers raises the difficult problem of combined roller adjustment ; small differences in the angle β between the settings of the various rollers at the contact position produce sliding as well as rolling motion, with the consequent risk of damage to the shaft and roller surfaces.

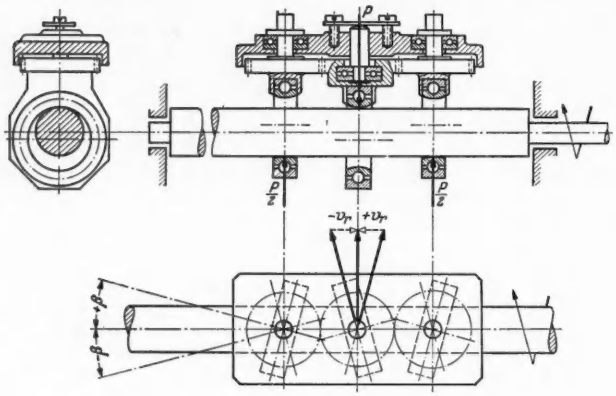

Fig. 2. **Schematic arrangement of a rolling-ring drive.**

In the newly developed transmission mechanism, the solid rollers have been superseded by rings encircling the shaft, against which their inner surfaces bear. In this manner, it has been possible to increase very considerably the overall performance and power-transmission capacity of the drive.

An arrangement of three rings side by side has been found particularly suitable. For instance, as shown in Fig. 2, the two outer rings may be arranged to bear in an upward direction against the rotating shaft, while the central ring exerts pressure in the downward direction. In order to be able to rotate together with the shaft, the rings form the inner races of ball bearings. The pivot axes of the ring carriers are parallel, and the supporting arrangement is mounted on one side on a common mounting-plate. The pivot axes are operated by a train of three gear-wheels, in such a way that when the pitch, i.e., the angle of rotation, is altered by varying the angular setting β of one of the pivots, adjacent rings will be pivoted through the same angle but in opposite directions. This drive, therefore, has the same properties as that of Fig. 1. When the shaft rotates, the carriage can perform traversing motions of variable stroke and velocity in either direction. In addition, however, it can transmit much greater transverse forces than the solid-roller type of drive, because the latter operates with point-contact conditions at high angular settings. In the new type of drive, the roller rings are designed with crowned inner surfaces, which ensure line contact with the shaft at large angular settings β_{max}, i.e., at maximum velocities, so that a far greater amount of power can be transmitted.

The contact-pressure conditions are also more favourable with rings than with solid rollers, as will be seen from the following theoretical considerations. Point and line contact are obtainable only with infinitely rigid bodies. Actually, there are contact areas when the bodies are not infinitely rigid. According to Hertz, the contact area between two bodies with similar or dissimilar curvatures can be represented by the contact area of an equivalent sphere bearing against a flat surface with the same pressure. The radius ρ_n of this equivalent sphere is, in fact, a measure of the load-carrying capacity of the two bodies. This radius can be determined from the relations $1/\rho_n = 1/r_n \pm 1/R_n$, where r_n = shaft radius and R_n is positive or negative, depending on whether a roller (positive curvature) or a ring (negative curvature) is used.

It should be noted that, for cylindrical bodies in contact, the load-carrying capacity increases as the square of the equivalent-sphere radius ρ_n. For running surfaces with different curvatures in different directions the relationship is more complex, but, with a crowned inner surface of the ring set at a constant angle β relative to the shaft, the load-carrying capacity can be shown to be proportional to $\rho_n{}^k$, where k is an exponent greater than 2.

The diagram reproduced in Fig. 3 shows values of equivalent-sphere radius for various combinations of rolling bodies. The shaft (solid or hollow) is shown cross-hatched in all cases. As the purpose of Fig. 3 is to give a comparative assessment, the shaft radius r_n is in all cases taken as unity. The vertical axis gives values of ρ_n as functions of $\pm 1/R_n$ of

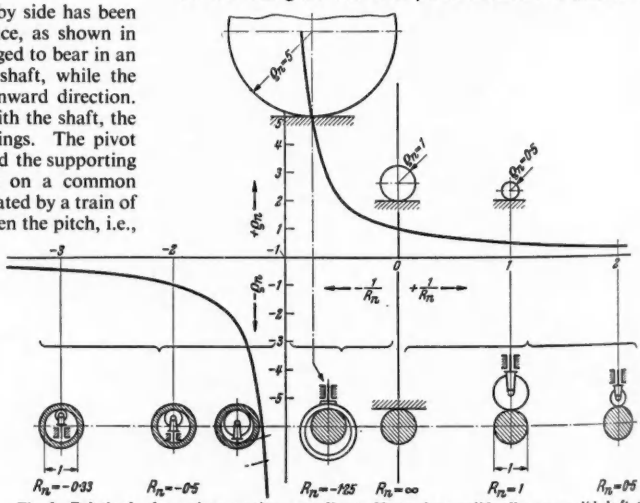

Fig. 3. **Relative load-carrying capacity, according to Hertz, for a solid roller on a solid shaft, a rolling ring on a solid shaft, and a solid roller in a hollow shaft.**

the radius of solid rollers and ring-type rollers respectively.

It can be seen that, when the roller radius is equal to the shaft radius, the radius of the equivalent sphere on a flat surface is $\rho_n = 0{\cdot}5$; this is approximately the ratio usually employed in practice. Proceeding towards the left, when the roller becomes much larger than the shaft ($1/R_n \to 0$), the equivalent-sphere radius approaches unity ; with rolling rings, the values of ρ_n then rise very considerably, thus indicating that far more extensive contact can be obtained with rings than with solid rollers on shafts. For instance, when $1/R_n = -1{\cdot}25$, $\rho_n = 5$ and therefore, as explained above, this ring and shaft arrangement is capable of carrying a load at least $(5/0{\cdot}5)^2 =$ at least 100 times greater than the solid roller and shaft arrangement with equal radii.

Thus, the values to the left of the zero-point on the horizontal axis are of interest for technical applications, in view of their extremely high load-carrying capacities. The diagram is also valuable as a further means of kinematic analysis, since it shows in its left-hand portion, for values of $1/R_n$ beyond -1, that there is another arrangement with high load-carrying capacity, i.e., that of the solid roller in a hollow shaft, which is the kinematic inversion of the external ring on a solid shaft.

A drive of this type, now used in practice, has been found capable of producing forces of 30 to 40 kg in the axial direction, for a shaft diameter of 30 mm. The construction is simple and compact, angular setting of the pivot axes being controlled by levers on top of the mounting-plate. Stroke length, velocity, and force transmitted are fully variable from zero to maximum values. This arrangement is of smaller size and is more compact than corresponding devices with solid rollers, because the rings, contrasted with rollers, are in positions of stable equilibrium on the shaft and need no special guide rods. However, a guiding arrangement can be incorporated when it is desired to regulate the contact pressure automatically as a function of external load.

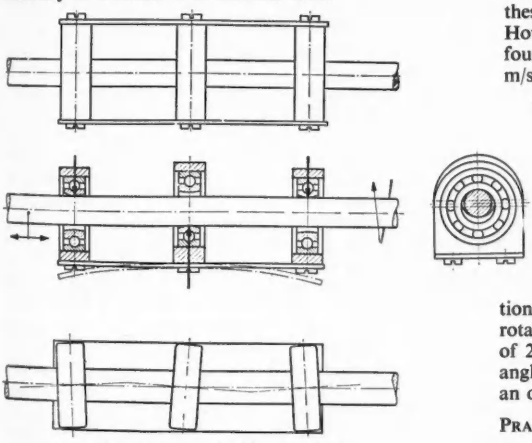

Fig. 4. **Simple models of rolling-ring drives.**

These ring drives are sturdy and require only minimum maintenance. The crowned running surfaces are admittedly not so easy to manufacture, but similar problems have been overcome with roller bearings and can also be solved in this case. The rings are made of ball-bearing steel and their running surfaces are hardened ; the shaft is of medium- or high-strength steel with a bright surface finish. The shaft need not be hardened or ground. Owing to the rolling loads, the shaft surface is actually made more compact through the operation of the drive, and it has been found that, after a period of running, small surface defects on the shaft disappear, as though smoothed out by cold-working. For drives with a particularly high performance, hardened and ground shafts can, of course, be recommended.

The drives should not be allowed to run completely dry. A thin film of oil, however, is sufficient to prevent damage to the running surfaces. Excessive oil reduces somewhat the transmissible power, although it does not make the drive inoperative. Most of the drives so far produced have been fitted with dust-proof ball bearings. Although the shafts and rings are not completely enclosed, no adverse effects have been observed in practice, e.g., in textile plants.

Power-Transmission Capacity

The power transmitted in the axial direction of motion depends on the contact pressure of the rings on the shaft. In the arrangement shown in Fig. 2, the centre ring is pressed against the shaft with a force P, while the shaft reactions result in forces $P/2$ on each of the two outer rings. These forces compensate one another in the mounting-plate. The coefficient of friction for steel on steel with slight lubrication has a value $\mu = 0{\cdot}15$. The axial force Q which can be transmitted during a traversing motion is therefore $Q = 2P\mu = 0{\cdot}3P$. Under dry-running conditions, the coefficient of friction (and hence the power transmitted) is approximately doubled. However, since all three rings contribute to power transmission the power output of the drive is already fairly high, and there is no need to increase it by resorting to dry-running conditions, with the attendant risk of surface damage. The power transmitted, which was 30 to 40 kg for a 30-mm diameter shaft, as mentioned above, can be increased to between 80 and 100 kg with a shaft of 40 to 45 mm diameter. Tests and development work on drives with these larger shaft diameters have not yet been completed. However, the drive with a 30-mm shaft diameter has been found in practice to be able to operate at speeds of about 1 m/sec, transmitting under these conditions 0·3 to 0·5 hp.

As the resultant of the contact force P and the axial force Q is in a direction only slightly different from that of the pivot axes of the rolling rings, the pivot bearings are, in effect, subjected only to loads in their axial direction, and this makes construction particularly simple, so that the rings can be supported on one side only. For precision drives, however, supports on both sides are an advantage. The high efficiency of the friction-ring arrangement can be appreciated from the fact that operation in reverse, i.e., the conversion of linear motion into rotary motion, is possible with a very small pitch angle β of 2·5 deg. The self-locking condition occurs only for angles β less than 2·5 deg., as compared with 12 deg. for an ordinary screw spindle.

Practical Applications

Possible applications of this drive are so varied that only a few can be mentioned in this article. These drives can be employed in practice in various sizes, as motion- or power-transmitting devices with fully variable characteristics. Fig. 4 shows, for instance, a very simple model with stationary rings (ordinary ball bearings) set at an angle to the shaft axis. In this arrangement, the common mounting-plate is designed as a leaf spring. This system operates in the same way as a low-pitch type

of screw spindle, without backlash or wear. The bearing housings may also be mounted on both sides on flexible plates, as shown in the upper part of Fig. 4. This model develops an axial thrust of about 12 kg, using a shaft of 11 mm diameter and bearings with an internal diameter of 12 mm. Pitch is adjustable but not accurate.

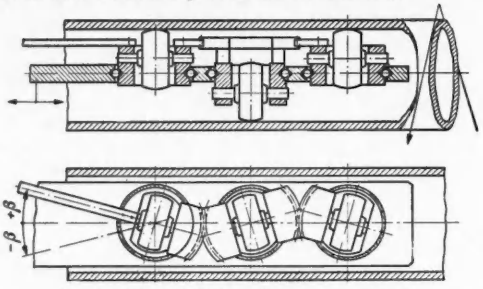

Fig. 5. Drive with friction rollers in a hollow shaft.

Another system is shown in Fig. 5, which has solid rollers in contact with the inner surface of a hollow shaft. This is an enclosed construction, which may be provided with either stationary rollers (internal screw) or adjustable rollers. Very little effort is required for drive adjustment. Even in the stationary condition and with very large drives, the setting angle can easily be adjusted manually. Because of this low power level for input adjustment, this mechanism can be used as a follow-up control, as a power amplifier, or as a reciprocating drive in control systems. It will operate with or without stopping at the limiting positions, with constant or variable power or thrust, and with similar or dissimilar velocities for advance and return motions.

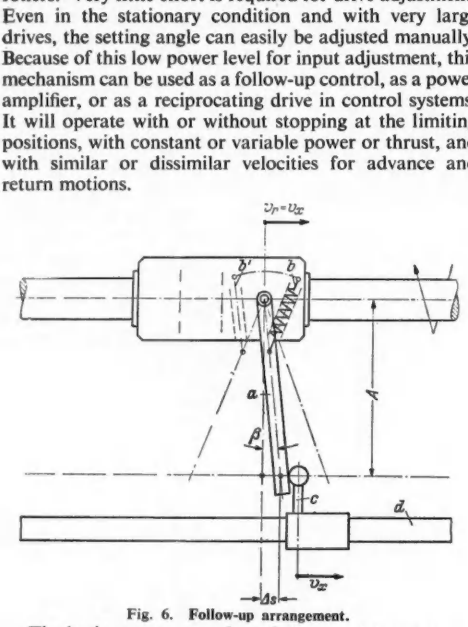

Fig. 6. Follow-up arrangement.

The basic arrangement for a follow-up drive is shown in Fig. 6. The control lever (*a*) is held by a spring (*b*) against a contact member or feeler (*c*), which the drive has to follow. If this feeler moves along the rail (*d*), the spring force will alter the position of lever (*a*) and the drive will run in the same direction as the feeler (*c*) and will follow it at the same velocity. The phase lag in the follow-up process can be easily calculated. The axial velocity of travel v_r depends on the controlling angle β to which the lever (*a*) is adjusted. If the feeler (*c*) contacts the lever at a distance A from its pivot, the lag in follow-up response will be $\Delta s = A \tan\beta$ but, since $v_r/C_1 = \tan\beta$, as mentioned previously,

$$\Delta s = Av_r/C_1 = C_2 v_r$$

The lag in displacement is proportional, therefore, to the velocity of displacement. By suitable choice of the values for the constants A and C_2, it is possible to control this lag within wide limits, i.e., it can be made extremely small or alternatively so large as to reduce any undesirable effects of irregular motions of feeler (*c*), such as those produced by rapid reversals. In this way, lag can be used to damp out troublesome vibrations.

When the feeler is stationary, so, too, is the drive, the control angle β and the response lag Δs becoming zero. If, at this position, suitable provision is made to cause the end of spring (*b*) to move suddenly to another position, such as (*b'*) in Fig. 6, the lever will also be reversed, moving away from the feeler (*c*) and operating the drive in the opposite direction of motion. This motion will continue to travel towards the left until the lever comes up against a similar reversing device. In this way, the drive will either remain stationary or, if the spring jumps back to its original position (*b*), a return motion will again be performed. In practice, reversal is obtained by means of a conventional quick-acting device.

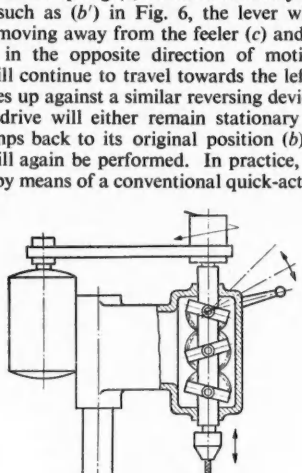

Fig. 7. Rolling-ring drive in a drilling machine.

For most cases, particularly when slow traverse is required, this simple reversing arrangement is sufficient. For rapid traverse and where large masses have to be displaced, the reversal of motion should take place more slowly, i.e., with lower acceleration. This can be achieved by making the lever (*a*) in Fig 6 sufficiently long or by allowing it to slide on suitably shaped cam contours which provide the desired reversal conditions at the limit positions.

The arrangement shown in Fig. 2 has proved very successful in knitting-machine drives, in which it provides impact-free reversal at the limit positions. The working width is controlled by adjustable curved limit-stops, which enable the machine to follow closely the requirements of the knitting pattern. Speed is adjusted by a lever on the traversing drive and is variable between zero and 1 m/sec. Normally, the machine is driven by an electric motor which rotates the friction wheel directly without intermediate wheels.

The versatility of ring drives is particularly evident in applications for machine tools. In a drilling machine (Fig. 7), the friction rings are situated at fixed positions in a casing and the spindle performs axial motion. The feed-control lever, which is operated either automatically or by hand, permits fine adjustment of the rings and

(*Concluded on page 522*)

Determination of the Yield Point of Steels by Magnetization

By P. Reti. (From *Acta Technica*, Vol. 15, Nos. 3–4, 1956, pp. 347–357, 10 illustrations.)

The accurate determination of the yield point of metals is a difficult problem, particularly with certain materials for which the yield point is not well defined. Good results can, however, be obtained by means of a non-destructive method suitable for various groups of ferromagnetic materials, e.g., steels with low carbon contents, chromium steels, chromium-vanadium steels, and manganese steels. In this method, the yield point is determined by measuring changes in permeability, using a d.c. permeameter.

The usual types of permeameter can be employed only for materials of comparatively low permeability, since they tend to give erroneous results for permeability values exceeding 10^4. Moreover, they require testpieces at least 30 cm long, with a cross-sectional area disproportionately large in comparison with the length.

It was therefore found necessary to develop a permeameter which would be suitable for smaller specimens and which would permit measurements of permeabilities up to 10^5. The basic principle of this instrument can be derived from a consideration of Fig. 1, which shows a portion of the testpiece, through which there is a flux density B in the longitudinal direction. This flux density can be measured accurately by means of a fluxmeter or a ballistic galvanometer. The field strength H can be determined from the leakage flux B_z which emerges from the surface of the material. Along a closed path, which encloses no current, the line integral of the field strength is zero. In other words, the resulting magnetizing force M has a zero value. Such a path is denoted by *a-b-c-d* (dotted lines) in Fig. 1. The line integral can be expressed as $M_{ab} + M_{bc} + M_{cd} + M_{da} = 0$. If the values of M_{ab} and M_{cd} are reduced to zero, this gives the relation $M_{bc} = -M_{da}$, which can be used to find H, since the lengths bc and da are known. Thus, the magnetic field strength inside the material can be obtained from this relation, since it is known that the tangential component of H is continuous at the boundary, i.e., that its magnitude and direction on the surface of the testpiece or in its immediate vicinity are identical with those existing inside the material.

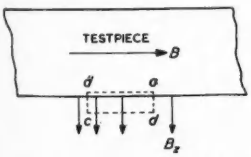

Fig. 1. Flux density B and leakage flux B_z emerging from the surface of a material.

There were some initial difficulties in the determination of the field strength, because demagnetizing poles are formed at the positions where the flux enters and leaves the surface of the material ; in many cases the fields due to these poles are equal to the applied magnetizing field. This difficulty could be avoided, in principle, by using toroidal, ellipsoidal, or very slender rod-shaped testpieces, so as to obtain a closed path, but these shapes are not easily produced, and it is desirable to retain the normal design of tensile test specimens.

The equipment comprises (1) a measuring element, described below ; (2) two magnetizing coils for d.c. magnetization ; (3) an oscillator, which excites the core of the measuring element at a frequency of 4000 cps ; (4) a filter, through which the output from the oscillator is passed before being applied to the measuring element ; (5) a de-energizer ; (6) an amplifier ; and (7) an oscilloscope. The purpose of the filter is to suppress the second harmonic of the oscillator output voltage ; tests with a wave analyser have shown that this harmonic was effectively eliminated.

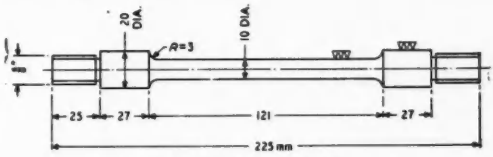

Fig. 2. Dimensions of standard testpieces used.

The test specimens were made according to the drawing in Fig. 2, the gauge length of the specimens having a diameter of 10 mm. The d.c. magnetizing coils, designed as plug-in half-coils embedded in plastic, are fitted around the outer portions of this gauge length, while the measuring element is mounted on the surface of the middle portion in the axial direction, and secured in the required position by means of a bakelite casing of adequate thickness with a hinged semi-cylindrical cover.

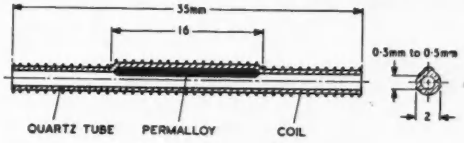

Fig. 3. Details of measuring element.

The measuring element consists of a solenoid wound on a quartz tube of the dimensions given in Fig. 3. The middle section of this tube contains an iron core, i.e., a fine wire of permalloy, 0·06 mm in diameter, which is fitted in a minute internal groove inside the tube. The solenoid is made of enamelled wire 0·01 mm in diameter. In order to obtain maximum measuring accuracy, the quartz tube cross-section is made as uniform as possible ; otherwise, the field of the solenoid cannot be expected to be homogeneous. The coil is excited by the filtered output from the 4000-cps oscillator.

The test procedure is as follows :—The measuring element is first tested by itself without premagnetization, the permalloy core being magnetized by the current to an equal extent in both directions of the magnetization curve. The measuring element is then fitted onto the surface of the magnetized test specimen, which is excited with direct current. The test in this condition shows a displacement of the zero point of the a.c. magnetization curve. Owing to this displacement, the voltages at the poles of the coil become asymmetric and contain even harmonics. The second harmonic was selected for indication purposes, since it is known that voltage amplitudes decrease with ascending harmonics.

The second-harmonic voltage at the poles of the winding increases proportionally to the field strength, if the latter is small compared with the saturation field strength of the magnetized measuring element. Because of its small size, this measuring element is particularly suitable for permeability measurements, as it permits the study of changes of magnetic field strength over very small areas.

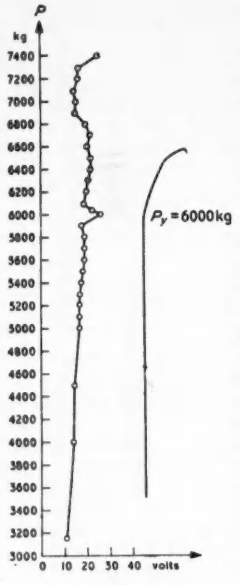

Fig. 4.

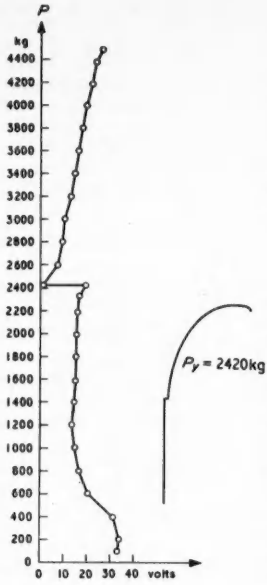

Fig. 5.

Fig. 4. Diagrams obtained with the permeameter and the tensile test machine.

Yield stresses : 30·8 (permeameter), 30·6 (Martens), and 30·8 kg/mm² (tensile test machine).

Fig. 5. Diagrams obtained with the permeameter and the tensile test machine. In the permeameter diagram, the yield point is clearly indicated.

Yield stresses : 76·5 (permeameter), 76·5 (Martens), and 74·6 kg/mm² (tensile test machine).

The following technique was employed in preparing the measuring element :—The air in the bore of the quartz tube was expelled by heating. The permalloy wire was then inserted into the tube and soldered in position, using a hydrogen flame. In the drawing operation required to obtain a diameter of 0·06 mm, the permalloy wire was exposed to severe mechanical stresses and, to recover the magnetism prior to exposure, it was therefore necessary to heat-treat it, together with the entire measuring element, at 1100°C. It was because of this high temperature that a quartz tube was used.

Determination of the Yield Point of Steels

The yield point of structural steels is usually determined from diagrams obtained from tensile test machines, from mechanical tensometers, or from the Martens mirror extensometer. The determination is made without difficulty if the steel has a well-defined yield point. The test is based on standard specifications ; for instance, Hungarian Standards prescribe 0·2% as the permanent extension for which the loads have to be determined.

With the permeameter, the yield point of steel specimens is determined from the changes in permeability which occur at the same time as corresponding alterations of length under load. To obtain comparative data, each specimen was tested by three methods, i.e., with the permeameter, the tensile test machine, and the Martens instrument. The rails of the mirror of the Martens extensometer were mounted on the heads, which are not subjected to elongation, while the permeameter was fitted on the gauge length of the specimen, as previously described. For each load condition, readings were taken from a milliameter coupled to the permeameter unit, at the same time as the diagram was being recorded from the tensile test machine.

Test Results

Two examples of the results obtained are shown in Figs. 4 and 5. In the course of this investigation, about 60 different specimens made from various unalloyed and alloy steels were tested. In all the diagrams obtained with the permeameter, the yield point was well marked, even when no marked yield point could be seen on the corresponding diagram of the tensile test machine. From comparisons of results for steels having a well-defined yield point, it was found that the yield point determined by the permeameter is the so-called " upper yield point ".

In most cases, the yield point appeared as a horizontal straight-line portion in the diagram of loads plotted against permeameter voltage. The direction of this line may be towards decreasing or increasing values of voltage (Figs. 4 and 5) ; the directional tendency may be due to the different magneto-elastic behaviour of various types of steel.

The values measured by means of the permeameter, the tensile test machine, and the Martens instrument show good agreement, particularly in view of the uncertainty of the yield points derived from the diagrams of the tensile test machine, and it can be said that the deviations due to experimental errors are within acceptable limits.

Further tests are planned in order to determine the magnitude of the changes in yield-point values produced by cold-forming and shaping processes, and to assess the extent to which results on the tensile test machine are affected by the rigidity of the machine itself.

The Rolling-Ring Drive for Converting Rotary into Reciprocating Motion

(*Concluded from page 520*)

hence of the spindle motion in the axial direction. The working stroke can be made as slow as required, with a high-speed return motion. This simple system operates without backlash and provides complete protection against excessive load. The rings may be supported either on one side only or on both sides. Other machines with a horizontal drilling spindle have been equipped with this drive, to give slow feed and quick return motion. The new mechanisms have also been incorporated in table drives in milling machines. On lathes, when this friction-ring drive is used, change-speed gears can be dispensed with and the lead-screw spindle can be replaced by a plain friction shaft. However, this arrangement cannot be used to cut accurate threads. Thrusts of 200 to 500 kg can be obtained with very practical drive dimensions.

Further applications include high-performance textile machines, wire-winding machines, carriage drives of office machines, and adjusting devices for optical and precision mechanical systems.

A New Electrolytic Cell for Isolating Carbides and Non-Metallic Inclusions in Steel

By N. BÄCKSTRÖM, S. HEISKANEN, and U. ILME. (From *Jernkontorets Annaler*, Vol. 140, No. 10, 1956, pp. 812–815, 3 illustrations.)

THE most commonly used method of isolating carbides and non-metallic inclusions in steel is that of dissolving the specimen electrolytically, the electrolytic conditions being so chosen that the matrix is dissolved and the isolated particles are left undissolved. The latter must then be collected in some way or other for further examination. In order to isolate the non-metallic inclusions, the residue from the electrolytic isolation is chlorinated in a vacuum by a special method which leaves the oxides unattached.

The electrolytic cell hitherto preferred, particularly for the isolation of oxides, is the Klinger-Koch apparatus, in which a protecting atmosphere can be retained during electrolysis. For the isolation of carbides, simpler cells are normally used, e.g., the type designed by Heiskanen*.

Since the cells now known do not always give satisfactory results, an attempt has been made to develop a new type of cell, which, according to earlier experience, should meet the following requirements :—

(1) The anode (specimen) should dissolve uniformly on all sides.
(2) The anode should be conveniently removable from the cell, in order to enable the loosely attached particles to be recovered.
(3) There should be a device for collecting the particles not adhering to the anode.
(4) The anode should be visible for good control of electrolysis.
(5) It should be possible to keep a protecting atmosphere in the cell.
(6) There should be possibilities of using different electrolytes in the anode and cathode compartments.
(7) It should be possible to remove the electrolyte continuously and to replace it with fresh solution.
(8) It should be possible to measure the pH of the catholyte and to keep it constant during electrolysis.
(9) The apparatus should be simple to handle, inexpensive, and built of as few specially made parts as possible.

The new cell, claimed to fulfil these requirements, is shown in Figs. 1 and 2.

The cathode, consisting of a platinum wire coiled on a glass-tube spiral, is placed around the anode. This gives a more evenly distributed current density on the " anode-specimen " surface and makes dissolution more uniform. The uniform current density also makes the conditions of electrolysis better defined, and gives better possibilities for a good isolation result.

The specimen is removable from the bath, and the isolated attached particles are thus easily recovered. During continuous electrolysis, when the isolated particles partly separate from the anode, they may be collected on a cella filter in the same way as in the Klinger-Koch apparatus. Instead of the cella filter, it is also possible to install a settling reservoir, in which the electrolyte and the small isolated particles pass through a narrow tube to the bottom of a larger tube, whilst the electrolyte is removed through an overflow at the top of the large tube. The anode is easily visible through the glass cell and the plexiglass tube.

Cellophane seems to be a very suitable diaphragm material, although it has to be moistened in water to make it conductive, if some other medium than water is used as an electrolyte. The cellophane film is wound around the plexiglass tube and the ends are put into a slit in this tube. The cellophane film is kept in place by means of rubber bands at the top, middle, and bottom end of the tube.

Through the glass coil cold water runs during electrolysis to prevent the temperature from rising above room temperature. According to the authors' experience, this is beneficial for electrolysis. On the other hand, if it is

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* *Jernkont. Ann.*, Vol. 139, 1955, pp. 78–134.

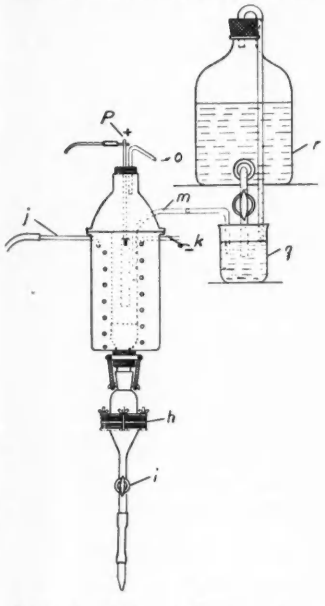


Fig. 1. General view of the apparatus.

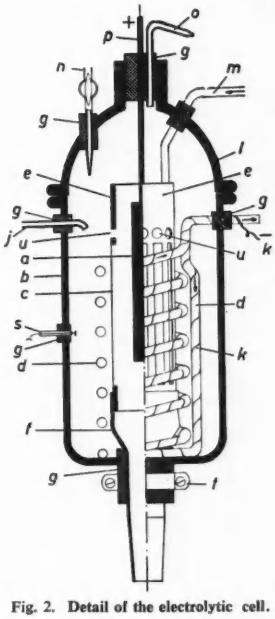


Fig. 2. Detail of the electrolytic cell.

a = specimen (anode) ; *b* = glass electrolytic cell ; *c* = cellophane diaphragm ; *d* = glass cooling coil ; *e* = plexiglass diaphragm holder ; *f* = glass funnel; *g* = rubber stopper ; *h* = filtering device with cella filter, according to Klinger-Koch ; *i* = glass stopcock ; *j* = protecting gas-supply tube ; *k* = cathode of platinum wire ; *l* = electrolytic cell cover ; *m* = electrolyte supply tube ; *n* = burette for supply of acid ; *o* = gas outlet ; *p* = specimen holder, also functioning as current lead ; *q* = vessel for adjusting electrolyte level ; *r* = electrolyte storage bottle ; *s* = two electrodes (platinum and calomel, side by side) for possible measurement of the pH of the electrolyte ; *t* = stainless-steel clamp ; *u* = holes in diaphragm holder.

U. S. A.

Additives in Steel-Mill Lubricants

By M. S. Clark. (From *Iron and Steel Engineer*, Vol. 33, No. 10, October, 1956, pp. 87–93).

Additives are of definite value in improving many of the properties of lubricants and in increasing their life. In discussing some of the theories used to explain why these materials are effective, this article points out that many factors must be considered, and that the use of additive concentrates should always be under laboratory control.

Additives have been used in lubricants quite extensively for the last twenty years, and their use seems to be increasing. This is primarily due to the modern tendency to speed up machines to the point where additives are necessary to lubricate properly under extremely heavy-duty conditions. The day may not be too far distant when practically all lubricants will contain additives of one kind or another. Comparatively small concentrations of additive in the range of 0·01 to 5% are usually sufficient to provide the desired effect. It is estimated that approximately half the lubricants used in steel mills now contain additives. Each type has a specific purpose and all have proved effective in laboratory tests and in plant operations.

Extreme-Pressure Agents

It is of paramount importance that a lubricant should maintain a film between moving metal surfaces. Under operating conditions where the loads are low and clearances are relatively large, the problem is simply one of selecting the proper viscosity grade of oil. In service where pressures are high, however, as in hypoid-gear lubrication, the lubricant is forced out, and seizure of the metals may occur. Extreme-pressure agents were developed to eliminate seizure and to impart the necessary high load-carrying properties to the lubricant.

Several types of compounds have been found to increase these load-carrying properties. Certain phosphorus, sulphur, and chlorine compounds are very effective in reducing welding. Lead compounds, such as lead oleate or lead naphthenate, are also effective extreme-pressure agents. Certain combinations of two or more of the above agents often provide increased effectiveness. Incidentally, with regard to the theory that, with an extreme-pressure lubricant using lead naphthenate as the additive, the lead in the oil can precipitate out, it may be stated that the lead naphthenate now used by most oil companies is very stable, and there is little, if any, trouble with lead deposits. On the other hand, the original leaded lubricants contained lead oleate, and these used to give some trouble as the result of separation of lead compounds.

When bearings or gears are operating under thick-film or hydrodynamic lubrication, there is a sufficiently thick oil film to keep the surfaces apart, and extreme-pressure lubricants are not necessary. However, when loads are increased greatly or when speeds are decreased and boundary-lubrication conditions exist, the high spots on bearing or gear surfaces begin to rub against each other, and high localized temperatures will develop (estimated at up to 1800°F with steel-on-steel surfaces). If these conditions continue, the surface will become increasingly hotter, and seizure will eventually take place. Under these conditions, extreme-pressure additives react chemically with the hot steel, forming sulphide, chloride, phosphate, or lead compounds on the hot spots. These compounds protect the steel, preventing seizure and inducing lower temperatures.

With regard to the problem of depletion of the additive in service, it is true that the rougher the service the quicker will the additive be used up. While extreme-pressure properties in some gear sets may be depleted in, say, six months, in others they have retained their characteristics for years. This is due chiefly to the severity of the service to which the oil is subjected. If the service is extremely heavy, or if there is something mechanically wrong with the equipment, producing excessive heat or pressure, the additive will eventually be used up.

The question of compatibility is a serious one, and it is believed that most oil suppliers would caution against mixing two varieties together. Usually, the oils themselves, if they are brand-new, are compatible. Laboratory tests can be made to find out if they are. Mixtures can be put in bearings and operated for a while. They can also be heated up to see if any deposit is formed, and they can be cooled down to see if there is any adverse effect at low temperatures. There is definite opposition to adding a fresh oil to a used oil of another variety which may be contaminated. The fresh oil may cause precipitation of oxidation products and contaminants, causing sludge formation.

Insofar as the question of the mutual effect on each other of the additives in a product is concerned, it may be said that it is possible that one type of additive may have an adverse effect on another. Compatibility tests can, however, determine whether or not this is true in any given case.

Viscosity-Index Improvers

Viscosity index by itself is not indicative of the oxidation stability or performance qualities of a lubricating oil. Low-viscosity-index oils may give as good performance as high-viscosity-index oils. In machinery where starting temperatures are unimportant, such as stationary engines operated inside buildings, low-viscosity-index oils have been used extensively for years with excellent results.

In order to be able to extend the usable temperature range for oils for automotive engine service, and for hydraulic oil systems, however, where starting and operating temperatures are sometimes quite low, it has been found necessary to develop viscosity-index improvers. These materials usually consist of compounds of high molecular weight or polymerized materials. By using a viscosity-index improver, the viscosity at elevated temperatures within the operating range can be raised to assure more body in the oil film; nevertheless, the same oil at temperatures over the cold-starting range will be sufficiently fluid to assure easy starting and distribution throughout the oiling system.

Some viscosity-index improvers have a tendency to lose their potency with use; some lose it permanently and others only temporarily. Responsible oil suppliers recognize this problem and make sure their additives have good stability.

Pour-Point Depressants

Some lubricating oils contain wax, the presence of which raises the pour point of the oil. Although the

problem of pour has always been more or less in the minds of oil refiners and equipment users, the need for oils which would flow freely at extremely low temperatures was emphasized during World War II, when some army equipment had to be used in very cold climates.

Wax is removable by various methods but, in order to avoid the excessive costs involved where drastic dewaxing operations are needed, and at the same time to retain this high-viscosity-index material, pour depressants have been developed which reduce the pour point of wax-containing lubricants. These additives are usually condensation products of very high molecu ar weight.

Although a number of theories have been advanced to explain how pour depressants function, the most widely accepted is that these materials coat the surface of the minute wax crystals. In this way both crystal growth and oil absorption by the wax are prevented at reduced temperatures. As a result, no gel formation occurs, and the oil is free to flow at low temperatures.

Detergents

Detergents were the first type of additives to be used in diesel engines for the prevention of ring sticking and piston scuffing. The term detergent has since been used to classify additives which have the property of preventing the build-up of any deposits, or removing those already formed, e.g., sludge, varnish, lacquer, or carbonaceous products which interfere with the efficient operation of internal combustion engines. These materials, which originate from oil deterioration, as well as from combustion-chamber blow-by, are quite a problem, particularly in heavy-duty equipment.

Various metallo-organic compounds, such as phosphates, phenolates, alcoholates, naphthenates, and sulphonates, have been found very useful for this purpose. At one time it was believed that only certain soaps or salts of the alkaline-earth metals (calcium, barium magnesium, and strontium) were effective as detergents. Later developments, however, have revealed that soaps with a high molecular weight or organic salts of a number of other metals, such as tin and cobalt, also possess this desirable property.

The exact mechanism whereby a detergent functions is not too well understood, but it may involve either one or both of the following preventive actions, in addition to the possible cleansing action usually attributed to it:—

(1) Detergents may act as oxidation directors, so as to cause soluble oxidation products to form, rather than insoluble products.

(2) A chemical reaction may take place between the detergent and the potential lacquer, and between sludge-forming molecules, preventing them from becoming insoluble materials to be deposited on various engine parts.

These additives apparently have the effect of preventing deposit formation, as well as providing cleansing action. Detergents serve a very important function in promoting engine cleanliness properties of lubricating oils, especially for high-speed automotive and diesel equipment.

Dispersants

The action of dispersion in a lubricating oil is of a physical nature in that the products of fuel combustion, chiefly soot, together with some oil decomposition products, are held in suspension in the oil. This appears to be accomplished by the breakdown of these contaminating particles into a finely divided state, or maintaining them in their original colloidal state. By this action, agglomeration of the particles is prevented, with the result that oil filters and strainers remain unclogged for longer periods of time, and are thus better able to perform their function of removing from the oil stream any materials (such as dust) which might act as abrasives in the engine.

Anti-Corrosives

It should be understood that corrosion of bearings is generally attributable to a reaction between the acidic products of oxidation and one of the constituents of the bearing metal. For example, the mild acids formed by the oxidation of the oil will attack the lead in copper-lead bearings, taking it into solution and leaving a porous copper structure which will eventually crumble and break away.

Bearing corrosion may be controlled either by inhibiting oxidation completely, so that no acidic bodies are formed, or by laying down a protective film on the surface of the bearing, so as to prevent the acids from reaching the metal. Materials which function by forming such a protective coating are known as anti-corrosives or corrosion inhibitors. Compounds containing active sulphur, phosphorus, or nitrogen show the most promise in this respect. Materials containing sulphur seem to be especially effective, owing to their ease in forming protective films. These anti-corrosives may take the form of organic sulphides, phosphites, metal salts of thiophosphoric acids, and sulphurized waxes, to name a few.

It should be pointed out that anti-corrosives, by virtue of their film-forming properties, may also function as " poisons " for other metal surfaces in an engine. As a result, since the catalytic effects of the metal parts are decreased, the degree of oil oxidation may be reduced materially. It is obvious, therefore, that, when anti-corrosives are used in conjunction with anti-oxidants, bearing corrosion is reduced, while at the same time the life of the oil may be extended more than if an anti-oxidant were used alone.

Anti-Oxidants

Anti-oxidants are often added to motor oils, diesel lubricating oils, and heavy-duty gear lubricants and greases, all of which are used quite extensively in steel-mill lubrication.

A satisfactory lubricant must possess a number of characteristics, one of the most important of which is resistance to oxidation. Any lubricant which is exposed to oxygen (or air) at any temperature will eventually oxidize. The length of time before this takes place and the extent to which it occurs, depend on a number of factors, including temperature, presence of catalytic metals, presence of oxygen, and the inherent ability of the oil to withstand oxidation. The products of oxidation are complex materials, some of which may cause corrosion in copper-lead bearings.

Prolonged oxidation of the oil results in formation of sludge, which can cause clogging of oil lines and filters and which may make ball or roller bearings inoperative. The oxidized materials may, under high-temperature conditions, link together to polymerize, forming lacquer or varnish on pistons, cylinders, and other engine parts. Oxidation is promoted by the catalytic effect of certain metals, particularly iron and copper.

Many of the best types of anti-oxidants are organic compounds containing sulphur, phosphorus, or nitro-

gen, such as organic sulphides, phosphates, or amines. The mechanism by which these additives function is not too well understood. However, it is possible that the additive accepts oxygen in preference to the oil. Eventually, after extended use, the additive will become depleted, and the oil itself will begin to oxidize.

There are laboratory tests that will predict the effectiveness of an anti-oxidant additive. In one such test oil is heated for 40 hr, at 338°F. After addition of 1% additive to a straight mineral oil the amount of oxygen absorption was reduced by 70%.

Anti-Foam Agents

Oils used in gears and other equipment where oil gets whipped with air are apt to form foam, which may cause oil to boil out of the crankcase.

It has been found that minute quantities of certain types of silicones have the unique effect of "breaking" the foam as soon as it is formed. This is probably a surface-tension phenomenon.

Polar Materials

Fatty or other polar materials are useful in lubricants when load and speed conditions are severe and close to boundary conditions, and on the verge of needing an extreme-pressure agent.

These polar or oiliness agents are usually materials of high molecular weight, containing carbon, hydrogen, and oxygen, as compared with mineral oils, which contain only carbon and hydrogen. The polar oils also differ from mineral oils in one other respect, namely, that one end of the molecule is highly reactive and has the power of forming a powerful bond with the metal surface. These agents are called polar, because molecules are attracted to metal. The polar material is "adsorbed" to the metal surface so powerfully that the last traces can be removed by nothing short of grinding. The molecules attach themselves endwise to a surface and stick out like the flexible bristles of a brush.

Physical measurements have shown that polar molecules act in this way. The polar molecules of oleic acid, for instance, have been measured and found to be approximately one ten millionth of an inch in length.

Soaps in Greases

Oil-soluble calcium, sodium, lithium, and lead soaps are the types usually used in the manufacture of steel-mill greases. Of these, calcium-soap greases are comparatively insoluble in water and have low dropping points, usually around 200°F, while sodium-soap greases are soluble in water to some extent and have high dropping points, usually around 400 to 450°F. Mixed-base (sodium and calcium) greases have solubility and dropping-point characteristics which are intermediate between those of the above two greases.

Lithium-soap greases are less soluble in water than the sodium-base type, but have dropping points of around 350 to 450°F. Lead soaps are usually added to greases to provide extreme-pressure qualities, in conjunction with sulphur or chlorine compounds.

Solvents

Solvents or thinners are sometimes added to heavy, viscous-type gear lubricants, to thin them and make them easy to apply. The thinners evaporate during operation, leaving a heavy lubricant coating on the gears.

Three types of solvents are used, i.e., (1) petroleum thinners, such as naphtha or Stoddard solvent, which are less volatile than petrol. Their chief disadvantage is that they are inflammable; (2) chlorinated solvents such as trichloroethylene, which have the advantage of being non-inflammable, though their fumes may be toxic to operators working in enclosed locations; and (3) coal-tar solvents, such as benzol, toluol, or xylol, which have the disadvantages of being inflammable and toxic.

Bactericides

Bactericides are often added to soluble oils to prevent the formation of bacteria producing bad odours in emulsions. The bacteria usually originate from some other outside contamination. The soluble oils themselves do not contain bacteria.

Rust Inhibitors

Several types of inhibitors are used in slushing oils, rustproofing oils, and heavy rustproofing compounds, to protect against rusting in the presence of water. Fatty or other polar materials have the property of plating out on metal, providing a protective film. Emulsifying materials such as sulphonates or water-soluble soaps permit water to be emulsified, keeping the water from contact with the metal.

Certain types of salts also protect against water corrosion, forming complex coatings which prevent further rusting.

Solids

Finely powdered copper, zinc, lead, and graphite are often blended with greases to make pipe-thread lubricants. The solids prevent galling of threads when joints are tightened and provide sealing action against high pressure. They also facilitate unscrewing when disassembly becomes necessary.

Calcium carbonate, zinc oxide, talc, and graphite are also used in hot-punch compounds in shell manufacture. The solid material prevents metal-to-metal contact, provides good finish, and facilitates removal of the punches from cavities.

Recently, molybdenum disulphide has received considerable attention as a solid-type additive in greases and oils. Although some very interesting results have been claimed for this material, the real benefit to be gained is still a subject of considerable investigation.

The demand for greases with high dropping points, suitable for hot applications, has led to the use of solid thickeners such as clay and silica to replace soaps. These greases have found acceptance in steel mills for lubricating coke-oven doors, for cooling bed bearings, and for other very hot locations.

Misuse of Additives

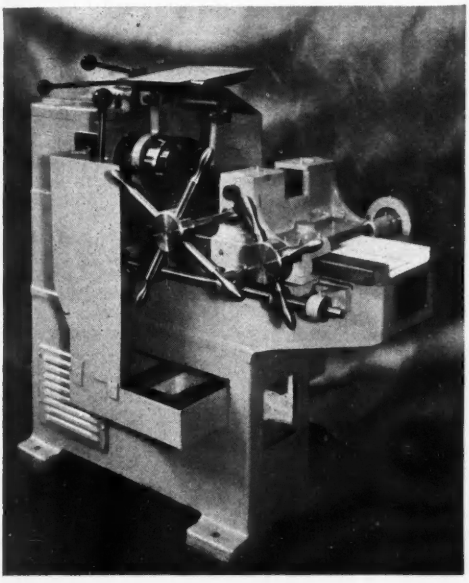
The application of additives to lubricants should be a very carefully controlled procedure. The lubricant manufacturer has many factors to consider. Some oils are more difficult to inhibit than others. Too much additive is a waste of money and may actually degrade an oil. If more than one additive is used, the effect of one must be balanced carefully against the others, to obtain optimum results.

The use of additive concentrates in used or reclaimed oils should always be under laboratory control, since the balance may be faulty, too much may be used, or the oil may be degraded, instead of improved. In general, such practice should be discouraged, since a careful study will usually reveal that costs exceed savings.

British Industrial Developments

Screwing Machine with Thread-Rolling Diehead

Details of modifications to their 1-in. automatic bolt capacity screwing machines for fitting a thread-rolling diehead are announced by Joshua Heap & Co. Limited, of Ashton-under-Lyne. The thread-rolling head has a capacity of $\frac{5}{16}$ to 1 in. B.S.W. and is fitted with an automatic opening and closing device. An internal trip to the diehead can be fitted for short lengths of thread.



The gearing in the all-geared headstock and the V-rope drive ratio have been modified to give a range of four spindle speeds between 250 and 1000 rpm. All shafts, including the main spindle, run in ball and roller bearings, and a 5-hp motor is fitted. The work is held in an open self-centering box-type vice of extremely robust construction. The vice is opened and closed by left- and right-hand Acme screws operating in the same plane as the axis of the piece to be gripped, thus eliminating any tendency of the vice to lift. All the operating mechanism is totally enclosed, minimizing damage and wear from swarf and preserving its accuracy over a long period. A coolant pump and self-contained tank for the thread-rolling lubricant are fitted, and the machine is supplied complete with all the necessary splash-guards, operating keys, etc.

Silicon Junction Rectifiers

Following on its range of germanium junction rectifiers, The British Thomson-Houston Company, of Rugby, has developed a series of low-power silicon junction rectifiers which will offer many advantages where high-temperature working and small size are required. With these silicon rectifiers, a maximum junction temperature of 200°C is possible, allowing operation in ambient temperatures up to 175°C. At these high temperatures, inverse voltages up to 300 V are possible; alternatively, if the maximum junction temperature is limited to 120°C, allowing operation in ambients up to 100°C, a higher inverse voltage is possible, and units are being made up to 400 V. Another important application of the silicon rectifier is as a voltage reference (Zener diode), particularly in the range of 4 to 8 V. Such units have also been developed, and are suitable for junction temperatures up to 250°C.

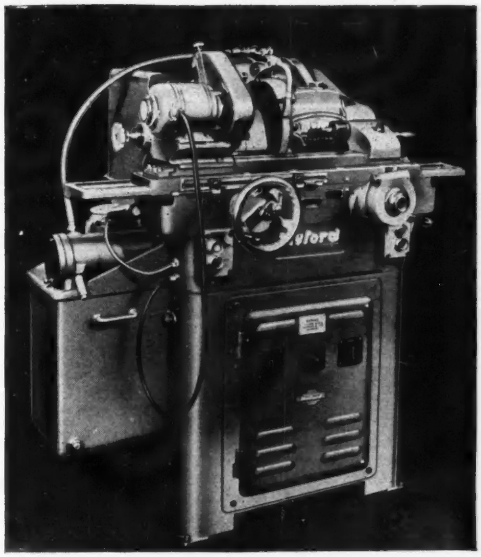
All these units, which are now available in experimental quantities for use in development work and in prototype production, are encapsulated in identical fashion. They are fully hermetically sealed by means of a projection weld, and are being made in three forms, i.e., wire-ended, stud-mounted with top flying lead, and stud-mounted with top soldering tag.

Cylindrical Grinding Machine

Designed for toolroom or production work where a smaller machine is required as basic equipment or as an auxiliary to machines for higher production, the latest MG12 cylindrical grinding machine manufactured by Myford Engineering Co. Limited, of Beeston, Nottingham, fills the need for a relatively low-priced manually operated machine capable of accurately grinding small workpieces.

Table movement is by rack and pinion. Epicyclic gearing is provided in the handwheel, giving either 1·7 or 0·575 in. of travel per revolution of the handwheel. The flat and vee ways are lubricated by oiling rollers and are fully protected against splashing. The table deadstop is retractable. The worktable can be swivelled (up to 5 deg. either way) for grinding tapers. Engraved plates are provided at each end to assist in obtaining settings, indicating the included angle in degrees and taper per foot.

The main dial of the wheel-feed mechanism indicates 0·0001-in. increments of infeed, and a dead-stop is provided for repetition work. Provision is made for the initial setting of the handwheel abutment in relation to the dead-stop, and for wheel-wear compensation. Extremely fine settings can be obtained via a separate



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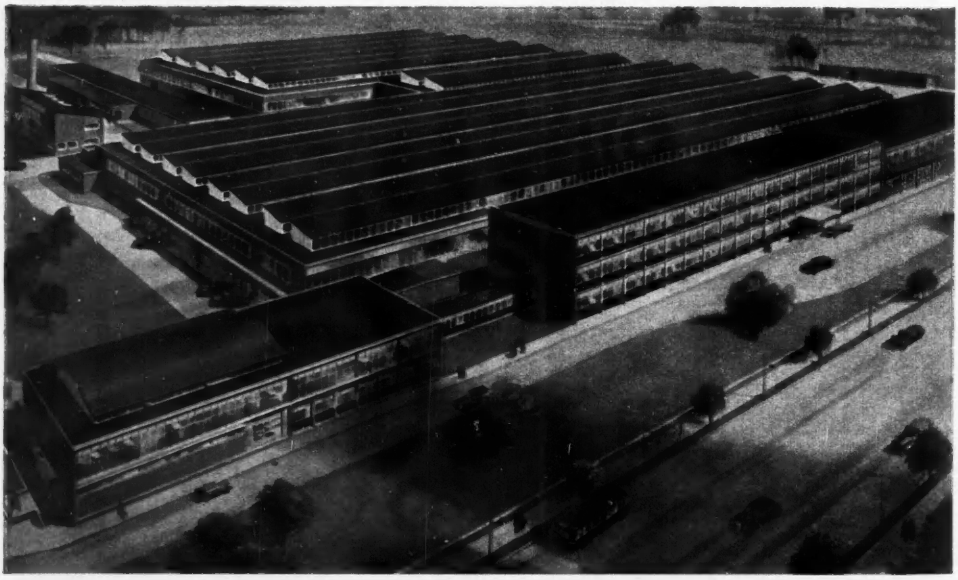

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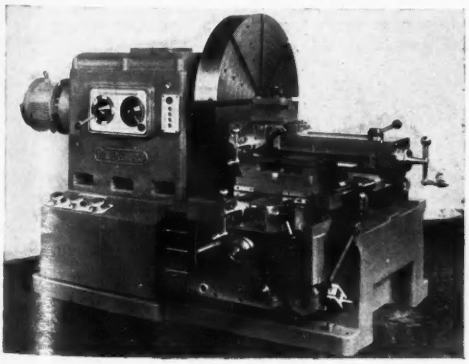
graduated control which represents only 0·0002 in. infeed per complete revolution. A stabilizing weight is fitted to ensure constant loading of the feed-screw over the whole range of feed.

The cartridge-type nitralloy-steel wheelspindle permits easy replacement, while adjustment is very simply effected by means of a graduated collar. An oil reservoir, an oil filter, and a circulating system with a visible return flow ensure maximum safety in lubrication. The grinding-wheel spindle is driven by an endless flat belt. Two wheel speeds provide a high degree of wheel efficiency and economy. The work speeds are arranged in two ranges of six speeds, the appropriate range being set by V-belt transfer, and the individual speeds by an electrical selector switch. No gears are used in the workspindle drive. Collets with a capacity up to ½-in. diameter can be placed directly into the bore of the spindle. Self-centering 3-jaw and independent 4-jaw 3½-in. diameter chucks can also be supplied. A feature of the machine is the optional provision of a removable internal-grinding attachment, with a capacity of 0·25 to 3 in. diameter and a grinding depth up to 3 in.

Facing Lathe

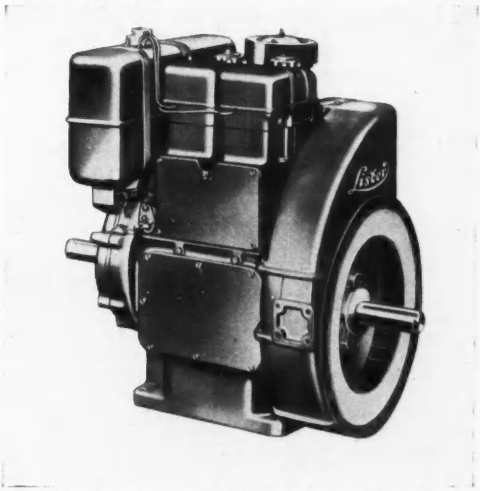
Details of the new type KT.45 facing lathe manufactured by Maschinenfabrik Ravensburg A.G., of Ravensburg, Germany, are announced by Mortimer Engineering Co., of Harlesden, London, N.W.10, sole agents in the U.K. Designed for the machining of short workpieces with turning diameters up to 40 in. in diameter, e.g., flanges, rings, turbine cages, and similar components, the new lathe covers the requirements for high-speed metal removal on irregularly shaped workpieces of varying hardness.

As distinct from previous bed-type facing lathes, the carriage of the KT.45 lathe is operated from the front. As a result, there is no obstruction of observation of work and tool during facing operations, and access to the workpiece when taking measurements is facilitated. The bed is short, extremely wide, and very rigid, with chip openings between the shears. The carriage is wide, with a long cross-slide for long cross traverse, while the two outer bedways extend past the faceplate and are fully protected against swarf by the carriage wings. The main movement of the carriage is across, i.e., parallel with, the plane of the faceplate. Feed to the tool parallel with the centre-line of the machine is obtained by the travel of the top slide, short workpieces requiring a short sliding motion only. Power feeds are provided to the carriage for the surfacing motion, and to the swivel-slide for the sliding motion and for taper turning. The cross-slide has a rear extension for mounting an additional toolpost or a single-coordinate copying attachment. The complete carriage, i.e., saddle and apron, can be moved on the bed by hand through a traverse screw, to suit the width of the work. The machine has a hand-operated top slide on the main bed for use with workpieces of various heights from the faceplate, automatic feed of the lower slide for large surfacing cuts, and automatic feed on the saddle for longitudinal surface and taper turning with covered compound slides, with extended lower slide and bed slide. Twelve spindle speeds and twelve automatic feeds are provided, the range of spindle speeds being from 8·4 to 380 rpm.



Twin-Cylinder Air-Cooled Diesel Engine

An entirely new twin-cylinder air-cooled diesel engine, suitable for powering a wide range of stationary and portable plant, is announced by R. A. Lister & Company Limited, of Dursley, Gloucestershire, and is now in production at the Wroughton (Swindon) small-engine factory of the Lister Group. The horsepower of the new engine ranges from 3 hp at 750 rpm to 7 hp at 1800 rpm on a 12-hr rating. It is capable, however, for periods of one hour, of developing a brake horsepower which is 10% in excess of the rated horsepower. Continuous brake horsepower, the maximum recommended for runs of more than 12 hours duration, represents 90% of the rated horsepower.



A direct development of the well-known Lister single-cylinder air-cooled diesel engine, this twin-cylinder model, which is of robust construction yet has a dry weight of only 370 lb, is a four-stroke engine of 3 in. bore and 3½ in. stroke, with a capacity of 49·48 cu in. Brake mean effective pressure is 64 psi at 1500 rpm, and the cyclic irregularity is 1/80 at 1500 rpm and 1/119 at 1800 rpm. The engine is governed to better than 4% steady variation when the load is on or off by means of a centrifugal governor mounted internally on the crankshaft. External provision is made for small adjustments of engine speed.

The direct-injection combustion chamber is located in the crown of each of the low-expansion alloy pistons, and combines low fuel consumption (0·53 lb/bhp per hour at full load) with excellent cold-starting qualities. An important feature of this combustion system is that the closed toroidal chamber in the piston head is used with a pintle-type fuel-injector nozzle, which has a single large hole and is capable of running for long periods without attention. The cylinders, cylinder heads, and injector sleeves are well finned for efficient heat dissipation, and cooling air is forced over them by a large flywheel fan through a cowling. Pressure lubrication is provided to the main bearings, big-end bearings, and rocker gear, with splash lubrication to the camshaft, cylinder walls, and small-end bush.

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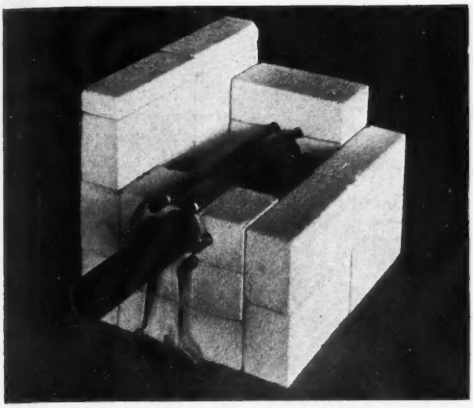
Electric Furnace Elements

Although The Morgan Crucible Company Limited, of London, S.W.11, does not build electric furnaces, it makes two of the principal materials used in their construction, i.e., refractories and electric furnace elements. The latter, "Crusilite," is the latest addition to their range of products and is the first electric furnace element to be made and sold by an English company.

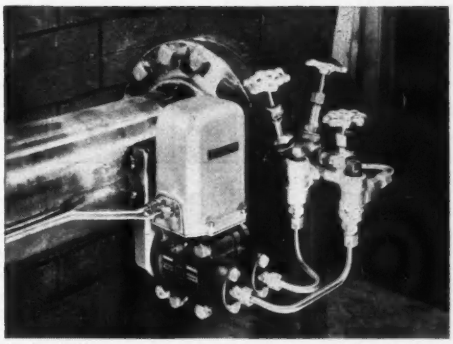


Crusilite elements are capable of being operated at temperatures up to 1575°C and comprise a one-piece silicon carbide element, as illustrated, of which the central hot zone is in the form of a spiral of the requisite length. They are made in five diameters (10 mm, 14 mm, 18 mm, 22 mm, and 28 mm), with a range of hot-zone and overall lengths to suit all popular designs of furnaces. The 10-mm and 14-mm sizes have special metal terminal-caps shrunk onto the metalized ends, ensuring a good electrical contact to the silicon carbide and providing an easy means of connecting them to the power supply. The method of manufacture permits the maintenance of a resistance tolerance of $\pm$ 10% of nominal and, where the manufacturer supplies elements as a set for a particular furnace, the resistance of individual elements will not vary by more than $\pm$ 5% of the mean. Such tight tolerances thus make it possible to improve temperature distribution within the furnace, particularly where the elements are connected in series. All silicon carbide elements increase in resistance with use but, in the case of Crusilite, ageing is so slow that a voltage reserve of only 40% is normally sufficient to maintain operating efficiency throughout the long life of the elements.

A further development of Crusilite which will make its appearance shortly is an element with a hot zone formed by two parallel spirals. This will enable both electrical connections to be made at the same end and will permit the use of silicon carbide elements in many furnaces to which conventional elements cannot be applied.

Differential Pressure Cell Transmitter

A new differential pressure cell transmitter of advanced design for the measurement of all types of flow and liquid level has been introduced by Foxboro-Yoxall Limited, of Merton, London, S.W.19. The function of the cell is to measure the differential pressure across an orifice or other restriction in a pipe-line, to determine the rate of fluid flow, or alternatively to measure the differential pressure between high and low taps on a closed vessel, to measure liquid level. The cell then converts this measurement into proportional output air pressure and transmits a pneumatic signal over a



single air line to one or more remote receiving indicators, recorders, and/or controllers.

The new differential pressure cell transmitter, known as type 13A, uses the same basic operating principles as the original Foxboro transmitters, but embodies a number of new design features, resulting in greater sustained accuracy and improved ability to withstand abnormal ambient temperature changes and differential over-ranges. These new features include the provision of a range rod which permits adjustment from 0 to 20 in. and from 0 to 250 in. water gauge, with an integral calibration scale to facilitate range changes in the field. In addition, an external zero adjustment is provided, making it unnecessary to remove the cover during installation or tuning-in operations. Another important innovation is the use of a twin-diaphragm capsule. This new pressure-sensing element consists of two stainless-steel diaphragms seam-welded to a stainless-steel core. A special shot-peening process distributes equally the stresses in the corrosion-resistant diaphragms. The space between the diaphragms is solid-filled with a temperature-stable silicone fluid which protects the two diaphragms from over-ranges on either side of the capsule and contributes towards inherent "noise"-filtering properties, thereby filtering out at the measurement point line disturbances which might prevent the transmission of clear signals to the control instrument.

The new cell transmitter, which is weatherproof and unaffected by dust, dirt, or corrosive fumes, can be mounted in any position and can be close-coupled with the orifice and flow line, as shown in the illustration, or mounted independently and connected by longer load lines.

Automatic Swarf-Oil Separator

Arrangements have been made by Sharples Centrifuges Limited, of Woodchester, Stroud, Gloucestershire, to supply in the U.K. the new "Ellerwerke" continuous and completely automatic swarf-oil separator. This compact, self-contained unit occupies very little space and, on installations which have already been made, it has been shown that, by arranging a simple conveyor system both for feeding the swarf to the separator and for returning the de-oiled swarf to a storage, baling, or transportation point, considerable saving of labour is effected, whilst the many difficulties associated with swarf handling become non-existent.

Separation of oil from the swarf is achieved centrifugally, the crushed swarf entering a perforated rotating basket via an automatic hydraulically operated feed and discharge ram. The ram reciprocates approximately a quarter of the basket depth at a rate of from 10 to 12 strokes per minute, this rate being adjustable to suit the material being treated ; thus, on the up-stroke, de-oiled swarf is pushed over the basket top to a collection point beneath the extractor and, with the return of the ram, a further quantity of oily swarf replaces the de-oiled swarf which has already been discharged. The swarf accord-

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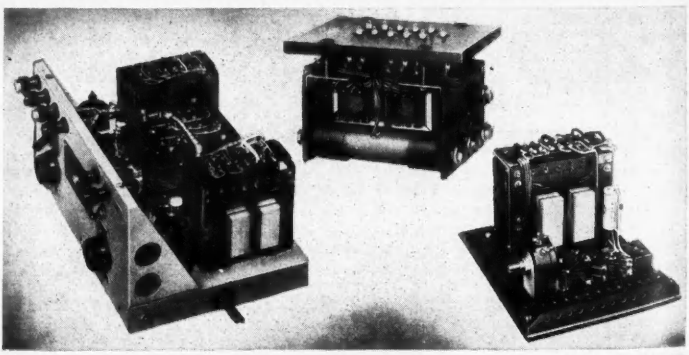

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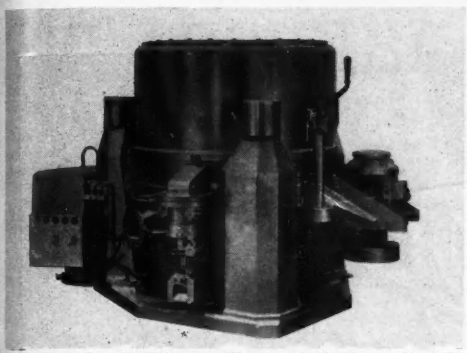


ingly loses its oil while travelling up the basket wall. After treatment, swarf contains as little as 1 to 2% of moisture. A feature of the design of this vertical separator is that the main working part of the unit is suspended from three pendulum bearings and thus, as opposed to the type of equipment with stationary bearings, the minimum of vibration is transmitted to the foundations, while high bearing stresses are eliminated and smooth running of the extractor is assured.

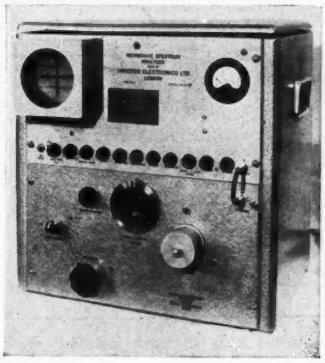
A range of four sizes is available, these being capable of treating from 1 to 8 tons per hour of crushed swarf (steel), 0·5 to 3·9 tons per hour (aluminium), and 1·1 to 8·7 tons per hour (brass).

Universal Spectrum Analyser

As a result of the success enjoyed by the Winston X-band spectrum analyser, a new universal instrument for the precision measurement of the spectra of pulsed signals in the S, X, and L bands is now being produced by Winston Electronics Ltd., of Shepperton, Middlesex. Designated the Winston universal spectrum analyser, the new instrument also acts as a sensitive receiver of the frequencies covered by these bands. The requisite spectra are displayed on a 5-in. long-persistence cathode-ray tube. The pictures are steady and bright, so that photographic recording equipment may be used with ease ; in fact, the bezel of the cathode-ray tube has been designed to enable recordings to be made with a Cossor model 1428 oscillograph camera.

The wavemeter operates in the TE_{011} mode and has a Q-factor of 15,000. The accuracy of absolute frequency measurements is $\pm$ 4 Mcs or $\pm$ 1·5 Mcs, according to the band. Relative measurements can be made to an accuracy of 250 or 150 kcs.

The equipment consists of an electronic rack and a micro-wave component section at X-band frequencies. The micro-wave component is mounted on the front panel of the electronic rack. At S-band, the radio-frequency components are mounted in a second rack. Both racks are fitted into a single case. The instrument, which is suitable for 19-in. rack mounting, is designed for the viewing of pulsed signals of pulse length ranging between 0·2 and 2·5 microsec at repetition frequencies from 200 to 3000 pulses per second. Both sections use a mechanically tuned local klystron oscillator which can be frequency-modulated over a range varying between 40 and 10 Mcs.



The saw-tooth of modulating voltage applied to the reflector to the klystron is derived from a Miller transitron oscillator, which also produces a horizontal reflection of the cathode-ray tube. The input signal, suitably attenuated, is mixed with the output of the klystron oscillator ; the resulting heterodyne output from the crystal mixer, which is frequency-modulated at the same rate as the local oscillator, is applied via a 70-ohm cable to a 20-Mcs I.F. amplifier, which has a band-width of 50 kcs. The output from the I.F. amplifier is mixed with a differentiated video signal from the crystal mixer, further amplified, and applied in push-pull form to the Y-plate of the cathode-ray tube. Since the deflecting voltage applied to the X-plate is also used to frequency-modulate the klystron, the horizontal deflection is proportional to frequency, while the vertical deflection is proportional to the vertical amplitude. Determination of the spectrum width and the centre frequency is obtained by means of a wavemeter pip with a pip-mark oscillator for S-band measurements at intervals of one megacycle. The signal from the transitron time base mixed with a video signal applied to the Y-plate is applied to the grid of the cathode-ray tube, providing both blanking of the fly-back trace and intensification of the brilliance of the spectrum pulses. For checking the operation of the local oscillator, the local oscillator current can be displayed on a meter, and the klystron modes can be displayed on the Y-plates of the cathode-ray tube.

All the essential power supplies, including the klystron, are electronically stabilized. An independent mains transformer provides E.H.T. for the cathode-ray tube. The klystrons are held in a well-screened mount and any undesirable thermal drift after a 15-min. warming-up period is eliminated.

A New Electrolytic Cell for Isolating Carbides and Non-Metallic Inclusions in Steel

(*Concluded from page 523*)

desired to electrolyse at a higher temperature, the coil may be used as a heating device. A protecting gas can be led either into the upper or the lower part of the cell, serving in the latter case as a stirring device.

When different solutions are used in the anode and cathode compartments, the cellophane diaphragm must cover the holes (*u*). The anolyte is in this case directed into the anode compartment, as shown in Figs. 1 and 2. When the same solution is used both as anolyte and catholyte, the holes are cut open, and in this case the electrolyte is most suitably led into the cathode compartment, whence it is passed through the holes into the anode compartment and finally out through the cella filter.

When only a weak, non-complex-forming acid is used, the pH of the solution must be kept below a certain value to prevent the formation of iron hydroxide. The pH of the catholyte has a tendency to rise during electrolysis ; in such cases pH can be measured by means of the electrodes (*a*) and a potentiometer, and, in order to keep it below a certain value, a weak acid solution can be added from the burette (*n*). In the latter case, it is advisable to stir the catholyte by passing the protective gas through the solution.

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CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

COMPRESSORS

Self-Excited Vibration of Axial-Flow Compressor Blades.
By A. D. S. CARTER and D. A. KILPATRICK. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, December 7, 1956, 20 pages, 25 illustrations.)

Blade vibration, with the possibility of a failure, is one of the major factors controlling the reliability of axial-flow compressors. Self-excited vibration occurring at part load, when some blade rows are stalled, often causes the most trouble. In this paper, an investigation into this phenomenon is described. The main objective has been to determine the major factors governing the vibration, and to establish, if possible, some design rules which would reduce the chances of a failure to an acceptable minimum. The self-excited vibration of blades in cascade has been studied, and a simple theoretical correlation attempted. This has been supplemented by single-stage work and by multi-stage full-scale tests. Both flutter and stall cell excitation have been encountered and are described.

It is concluded that there is obviously still much work to be done in connection with self-excited compressor-blade vibration. However, it is believed that the back of the problem has been broken, in that a reasonable understanding of the physical phenomena has now been obtained. It has been found possible to formulate a semi-empirical design rule which, it is hoped, will reduce to an acceptable minimum the chances of blade failure. The value of the rule should increase as experience in its use is obtained. The authors do not doubt that satisfactory compressors will be developed which will conflict with the rule, but design rules must represent a good average from which to start developing.

Using this rule, it has been shown that designing a compressor free from self-excited blade vibration need involve no serious compromise in contemporary design. Many compressors are safe, even though no special design precautions have been taken. Trouble has resulted from pushing the performance to the limit, and it is hoped that the results presented will give some indication of the risks which this entails in any particular application. Insofar as the future is concerned, it would appear that there may be some conflict between the purely aerodynamic demands associated with high performance and the design of mechanically satisfactory blades.

ELECTRICAL ENGINEERING

An Experimental Investigation of Subharmonic Oscillations in a Non-Linear System.
By K. GÖRANSSON and L. HANSSON. (From *Acta Polytechnica, Sweden*, Electrical Engineering Series, Vol. 7, No. 1, 1956, 16 pages, 13 illustrations.)

THE technical importance of non-linear phenomena is now generally recognized and there exists a vast literature on the subject. Acceptable theories have been given in very few cases ; many observations are still unexplained, while others have been described in a semi-mathematical way which is not always satisfactory. Concerning non-linear oscillations some (but too few) general mathematical results are known. A combination of theory and experiment has often proved useful.

There is one group of technically important phenomena which has been known for a long time but which still lacks a theoretical explanation, i.e., the forced subharmonic oscillations occurring in a non-linear system with positive damping. Besides mechanical applications, these oscillations have a special importance in electrical circuits containing an iron core near saturation conditions. A sufficiently small damping of such a circuit can result in high-amplitude oscillations at a fraction of the driving frequency, instead of the normal low-amplitude oscillation of driving frequency, which is the only one possible in a linear circuit. These subharmonics are rather disturbing wherever they occur, e.g., in loudspeakers, magnetic amplifiers, or electric power stations.

Many approximate theories for these phenomena exist. A practical method for evaluating the results of these theories was given by Knudsen in 1953. The methods generally rely on a Fourier-series approximation of the solution and a polynomial form of the non-linear characteristic. Apart from being mathematically unjustified, they are not suited to studying subharmonics of high orders, owing to the lengthy calculation involved. This situation has now, however, been improved considerably by Lundquist in 1955.

This paper describes experimental studies of forced subharmonic oscillations in an electric circuit containing an iron core. Electronic feedback is used for reducing the damping, and therefore measurements are possible at very low amplitudes of the driving voltage and at high-, up to ninth-, order subharmonics. The results are compared with Lundquist's theory and good agreement is obtained at small driving voltages, both regarding the amplitude of the oscillations and their general behaviour, e.g., existence in discrete frequency bands. Limitations in the valid.ty of the theory and the need for a large-amplitude theory are pointed out.

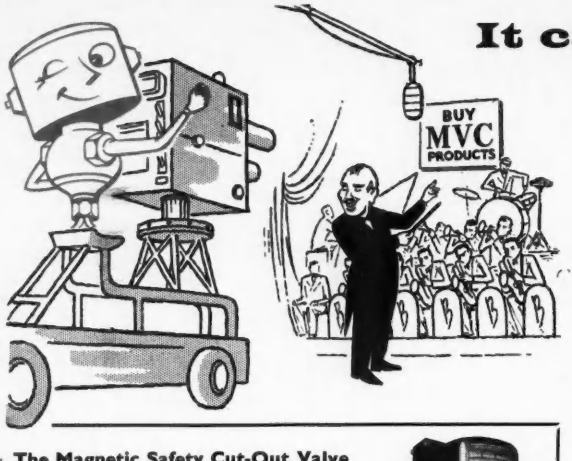
GAS ENGINEERING

Prediction of the Combustion Characteristics of Town Gas.
By M. G. GILBERT and J. A. PRIGG. (From a paper presented at the 22nd Autumn Research Meeting of *The Institution of Gas Engineers*, November 20 and 21, 1956, 48 pages, 19 illustrations.)

THE problem of the combustion characteristics of town gas is one which the gas industry in Great Britain has had under review for a considerable time. It is now becoming more difficult to obtain the best grades of gas-making coal, and alternative materials are being exploited, including non-caking coals, oil, refinery gas, methane from coal mines, and possibly natural gas, either from Great Britain or from oil-fields abroad.

The problem has arisen in an even more acute form in other countries. In the U.S.A. the change-over from manufactured gas to natural gas, and the problem of meeting peak-load demands, has stimulated interest in the subject, while in France gas has been produced from a very wide range of raw materials. The work of Weaver in America, and of Delbourg in France, have become associated with what is generally referred to as the interchangeability of gases. Both these workers have given methods by which the suitability of a gas for use in an existing supply can be assessed. The two methods appear to be very different, but it has been shown that they are similar in principle. The methods are difficult to apply directly to British conditions, for not only are appliances and burners different in the various countries, but so also are the test methods and methods of expressing combustion characteristics.

This paper is an attempt to combine the two methods and relate them to British conditions. Both methods are



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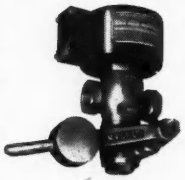

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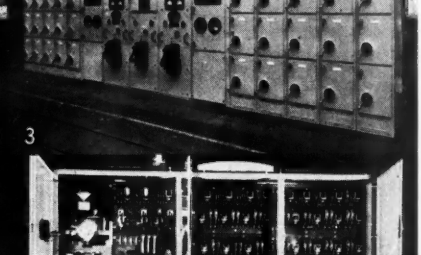

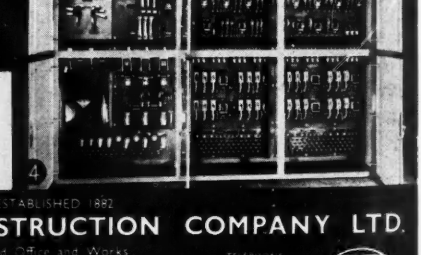

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largely concerned with the performance of an appliance on a gas relative to an adjustment gas, i.e., the problem of interchangeability ; this is probably the most important problem, but it is also important to know the combustion characteristics of a gas, in order that burners and appliances may be designed for it. The paper gives details of a method by which these combustion characteristics can be assessed by calculation from the analysis of the gas. A number of gases which are used or which have been proposed for use in the town gas supply have been examined by the method, and samples of some of these gases have been made up in the laboratory and their characteristics determined. Agreement between the predicted characteristics and those found is reasonably good.

The method involves the use of a calculated flame speed, and thus cannot be considered as completely satisfactory ; check testing of existing appliances therefore remains necessary. Nevertheless, the types of unsatisfactory performance that are liable to occur with a particular gas are indicated, and the testing of appliances on samples of the new gas can be reduced to a minimum.

GAS TURBINES

The Performance of Exhaust Systems for Gas-Turbine Aero-Engines.

By P. F. ASHWOOD. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, November 2, 1956, 18 pages, 17 illustrations.)

IN the early stages of development of the aircraft turbine engine, it was natural for effort to be concentrated on improving the performance of the three major components, i.e., the compressor, the turbine, and the combustion-chamber. Improvements were relatively easy to obtain and were immediately reflected in the test-bed performance of the engine. Little attention was therefore given to the exhaust system and propelling nozzle. Today, the situation is different, for not only has a stage been reached where significant improvements in the compressor and turbine efficiencies have become increasingly difficult to achieve, but also the advent of the supersonic engine has changed the relative importance of the components, with the result that a much greater emphasis has been placed on the need for obtaining a good performance from the exhaust system.

This paper summarizes published information concerning the aerodynamic performance of exhaust diffusers and propelling nozzles for turbine aero-engines, and extends and supplements this with additional data obtained from tests made at the National Gas Turbine Establishment. The factors influencing the exhaust-system design are reviewed, and the effects of the type of engine installation and the use of reheat are discussed. The influence of ducting losses on the thrust are then considered in terms of their effect on the performance of a typical turbo-jet engine.

A review is included of some previous work on turbine exhaust diffusers, concerned with the effects of the diffuser-area ratio and wall shape and with the effect of inlet swirl. This has since been extended by experimental examination of the influence of the bullet support struts on the performance of an engine, and the results of these tests are given.

Little published information is available concerning the performance of propelling nozzles over the range of pressure ratio relevant to the turbo-jet engine. The results of tests up to a pressure ratio of 9 on a series of convergent-divergent nozzles are given, and the effects of design pressure ratio and divergence angle are illustrated.

A one-dimensional theoretical treatment is used to show the relationship between the non-dimensional and specific thrusts and the applied pressure ratio. The test results are then analysed in terms of these thrust parameters and their related coefficients. The paper concludes with reference, in general terms, to some of the more important mechanical-engineering considerations in the design of exhaust-duct installations in jet-propelled aircraft.

ILLUMINATING ENGINEERING

The Noise Emission of Ballasts for Fluorescent Lamps.

By E. W. VAN HEUVEN. (From *Phillips Technical Review, Holland*, Vol. 18, No. 4/5, 1956/1957, pp. 110–119, 12 illustrations.)

UNLIKE incandescent lamps, gas-discharge lamps, such as tubular fluorescent lamps, cannot be directly connected to the mains but must be put in series with some type of ballast, to limit the current in the discharge tube.

With the increasing use of fluorescent lamps for indoor lighting more attention is being paid to the noise associated with these installations. The noise, which includes both low notes (hum) and high notes (rustle), originates principally in the ballasts. The cause lies in the alternating magnetization and the consequent deformation of the iron core of the ballast.

This paper discusses the nature of the noise and the manner in which vibrations of the ballast are communicated to the air, and deals with the theoretical aspects of core deformations. From these considerations, the precautions which can be taken to combat ballast hum are derived. In addition, the causes of rustle and means of combating it are discussed.

Ballasts vibrate with twice the mains frequency (producing hum) and also execute free vibrations of high frequency (rustle). Both forms of vibration result from the alternating elastic and magnetostrictive deformations due to the variations in current. High-frequency vibrations are directly transmitted to the air, while low-frequency vibrations are transmitted via the wall or ceiling. In ballasts with air-gaps (chokes), hum can be countered by filling the gap with a suitable material (mutual compensation of magnetostrictive and elastic deformation at the points of attachment). In ballasts without air-gaps (transformers), transmission of vibrations to the wall can be avoided by use of suitably designed brackets. Rustle can be combated by enclosing the ballast, surrounded by a sound-insulating material, in a box. The insulating material must, however, be heat-conductive ; aluminium foil has been found to answer the purpose.

INSULATION

Radio-Frequency Corona Resistance.

By M. OLYPHANT, JR. (From *ASTM Bulletin, U.S.A.*, No. 216, September 1956, pp. 47–55, 8 illustrations.)

ALTHOUGH electrical discharges of almost any sort can have a destructive effect on insulation, their behaviour and the nature of their effects depend to a considerable extent on frequency. At radio frequencies an arc clearly defined at 60 cycles tends to spread out around the high electrode and to disappear before reaching the ground electrode. At these frequencies the predominating type of discharge to which insulation is likely to be exposed is almost certainly surface corona.

The work reported in this paper was undertaken to study the effects of such discharges on various types of insulation. Although a wide variety of materials was studied in corona-voltage measurements, tracking tests were limited mainly to thermosetting materials, because of the difficulty of making reasonably reproducible tests on thermoplastics into which, for example, the electrode sinks as the specimen heats up. It is generally suspected that contamination is an important factor in most types of electrical surface breakdown, and some evidence of the effect of contamination is also reported in this paper.

Equipment developed for producing and metering 3-Mc corona discharges is described. The resistance of a variety of thermosetting materials to corona discharges was studied by determining tracking times at various current and power levels. These observations reveal interesting differences from low-frequency behaviour. However, it was also found that power levels producing failure in a given time are of the same order with either 3-Mc corona, 60-cycle arcs, or d.c. high-current pulses. This

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finding indicates that failure is principally dependent on the heat input to the specimen. The conclusion is reached that the most rewarding fields for further investigation lie in the study of the effects of much lower- and higher-power phenomena.

Also reported are the results of corona starting-voltage tests which reveal that this voltage is principally dependent upon, and can vary over a considerable range with, changes in dielectric constant.

IRON AND STEEL

The Nominal Cleavage Strength of Steel and its Importance for Welded Structures.

By T. M. NORÉN. (From a paper submitted to the *North-East Coast Institution of Engineers and Shipbuilders, Newcastle-upon-Tyne*, November 30, 1956, pp. 87–112, 18 illustrations.)

A CERTAIN property of steel, i.e., nominal cleavage strength, can be determined by means of tensile testpieces, on the edges of which a brittle alloy has been welded. On exposing these testpieces to an increasing tensile stress, cracks are continuously formed in the brittle layers of welding. At a certain critical stress a fracture will be initiated at one of the sharp crack fronts. The nominal cleavage strength of steel is defined as the highest nominal tensile stress a steel can withstand in the presence of a crack without the initiation of fracture at the crack front.

The nominal cleavage strength decreases continuously as temperature decreases, just as the conventional yield point increases continuously with decreasing temperature. If curves of these strengths are drawn, the point of intersection would appear to be a transition temperature for the steel, defined as the temperature above which plastic deformation can occur in a large volume of material, despite the presence of a crack, but below which only minor local plastic deformation is possible immediately in front of the crack.

By means of the method termed nominal-cleavage testing, results have been obtained which show a certain correlation to the results of impact tests, as well as to those of other brittle-fracture tests, e.g., Tipper and van der Veen. Moreover, the critical stresses for initiation and propagation of brittle fractures are shown by means of nominal-cleavage curves, as well as the influence of residual welding stresses. It is also shown that the quality of a steel with regard to its brittle-fracture tendency cannot be simply expressed by an impact transition temperature, as the critical stresses quoted above are not directly connected with the position of this temperature.

The Structure of Oxide Scales on Chromium Steels.

By H. J. YEARIAN, E. C. RANDELL, and T. A. LONGO. (From *Corrosion, U.S.A.*, Vol. 12, No. 10, October 1956, pp. 55–65, 5 illustrations.)

MANY investigations have been made of the protective oxides formed on heat-resistant alloys at high temperatures. The problem is so complex, however, that, even for the simplest of these alloys, no complete picture of the oxide-scale structure can be drawn for a wide variety of alloy compositions and exposure conditions. Most of the information now available is restricted to conditions giving rise to relatively high attack rates, and it is the object of the research described in this paper to obtain a sufficiently detailed description of the scale structure, in the case of simple chromium steels, to enable the essential correlations between oxide type and attack rate to be determined.

The structure of the oxide scale formed on commercial chromium steels containing 5 to 26% Cr, when oxidized in air or oxygen at temperatures from 700 to 1160°C for times up to 100 hr, was determined by X-ray diffraction methods, supplemented in some instances by chemical analysis. Two distinct types of scale were observed i.e., *A*-type scale, occurring when the rate of metal loss is less than approximately 10 mg/cm² per day; and *B*-type, when the attack rate is in the excessive range. For exposures near the critical conditions, an initial *A*-type scale transforms to *B*-type during oxidation.

The essential component of *A*-type scale is Cr_2O_3. This is usually accompanied by αFe_2O_3 in an amount which increases with the iron content of the alloy, i.e., with rate of attack. At high temperatures or long oxidation times, dilute solid solutions of each of these phases in the other are formed. When the alloy contains a few tenths percent of Mn, the *A*-type scale may also include copious amounts of $MnCr_2O_4$, especially for high-chrome alloys and for low-temperature oxidations in air.

B-type scale is more complex than *A*-scale and may be considered as two layers. The outer layer is duplex and is similar in all respects to the Fe_3O_4 and Fe_2O_3 layers of the scale on pure iron. The major constituent of the inner layer, corresponding to the FeO layer on pure iron, is a solid solution, $FeFe_{(2-x)}Cr_xO_4$, of the spinel type. Throughout most of the layer x varies slowly, but near the metal it rises rapidly to $x = 2$, and near the Fe_3O_4 layer it falls rapidly to $x = 0$. The mean value of x lies in the range of about 0·5 to 1·5. The greater the chromium content of the alloy, the higher is the temperature, and the longer the time of oxidation, the larger is the value of x. In cases of very high attack the series of spinels is accompanied by a series of wüstites, which are modified by chromium additions ranging downwards to zero at the Fe_3O_4 layer. For 10- to 20-hr oxidations at 925°C and at 1000°C, the chromium fraction of total metal in the inner layer is about 1·8 times its value in the alloy, whereas the excess is only about 1% in the scale as a whole.

The experimental data are compared and contrasted with existing information and are qualitatively interpreted by use of a tentatively proposed Fe-Cr-O phase diagram and a special theory of alloy oxidation.

VIBRATIONS

Optimum Design of Salomon-Type Pendulum Detuners.

By P. R. PASLAY and A. SLIBAR. (From *Ingenieur-Archiv, Germany*, Vol. 24, No. 3, 1956, pp. 182–187, 2 illustrations.)

THE Salomon detuner is a device which serves to suppress torsional vibration occurring at a critical speed of an engine system. It consists basically of a cylindrical roller of radius r (the " pendulum " mass) situated in a circular cavity of somewhat larger radius $r' = r + e$, provided at the bottom end of the crankweb, where the detuner device is fitted in the same way as a conventional balance weight.

In some papers, this detuner has been mathematically compared to a centrifugal pendulum, i.e., an equivalent compound pendulum with a disc rotating about the journal centre and carrying an oscillating lever with the pendulum mass at its lower end. In this paper it is shown, however, that the equations of motion of the Salomon detuner cannot be reduced to those of the usual centrifugal pendulum, so that the " equivalent-mass " treatment is not valid, even for a first approximation. The linearized and non-linearized terms of the equations of the Salomon detuner are derived and are used to obtain the required tuning condition, i.e., $n^2 = R/[e(z^2 + 1)]$ where n = order number of the critical to be suppressed, $e = r' - r$, and $z = k/r$, where k = radius of gyration of the roller mass. It is then shown that the detuner introduces another critical, of the order $2n$, i.e., which can be excited at an engine speed which is half that of the previously troublesome critical of order n. This $2n$-th order critical cannot be suppressed completely, but merely reduced to a minimum value, and the analysis indicates how the two remaining parameters for the Salomon detuner, i.e., the roller mass m and the n-th order phase velocity, can be utilized to minimize this $2n$-th order resonant condition. The results of this analysis of forced-vibration conditions should, therefore, give an improved basis for the design of detuners of this type.

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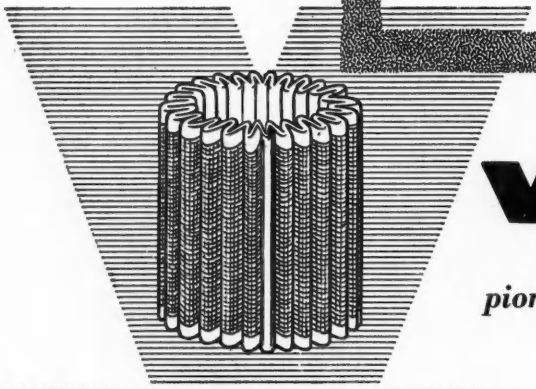

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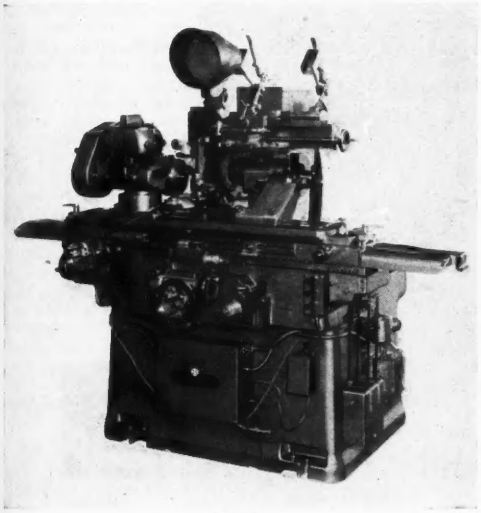


Fig. 1.

The wheelhead slide is long and projects into the recess under the main table slide. This slideway is mounted on anti-friction bearings constructed from balls and hardened-steel guideways, so that it is adequately responsive to fine increments of feed and fine settings concerned with work diameter. The wheelhead unit is arranged on a swivel in such a way that the wheelhead spindle is centered on the centre-line of the vertical swivel. Two wheels are provided, one at either end of the spindle, and these can be used in a swivelled position, without causing undue departure of either wheel from the optimum operating position. The wheelhead spindle is provided with a large-diameter accurately graduated indicating scale, co-operating with a vernier, to provide accurate angular setting. The wheel spindle is driven by a belt from a motor carried under the wheel slide, and is of the centre-driven type. The usual handicap of difficult belt changing when using a centre-driven spindle has been eased on this machine by an arrangement which allows the belt to be changed without disturbing the setting of the wheel-spindle bearings.

The feed mechanism consists of the usual screw and nut, and at the front of the machine is a control-box governing the rotation of the feed screw. This control-box is, in fact, a three-speed unit. A fast-feed handwheel, directly coupled to the feed screw, is brought into use by pulling out the handle with which it is equipped, automatically disengaging the other two finer feeds. The rate of movement of the wheelhead is $\frac{1}{2}$ in. per revolution of the handwheel (1-in. reduction in work diameter). When the handle on the main handwheel is pushed in flush with the front of the main handwheel, it is thus automatically removed from possible disturbances, and simultaneously picks up a fine feed to the nearest 0·1-in. reduction in diameter. This is the normal-feed handwheel used by the operator for control purposes. Beyond this rate of feed, a further fine feed can be engaged by a friction-clutch arrangement which enables the feed to be controlled from a small knob, with a control rate of 0·0001-in. reduction in diameter per revolution, and plainly graduated in large divisions showing 0·0001-in. reduction in diameter. In addition to the graduations on the feed dials, a system of secondary references is provided. Standard gauge-bars, giving combinations of lengths of 0, 1, 2, 3, or 4 in., are supplied, and are used in conjunction with a 1-in. micrometer, settable and readable to 0·0001 in., in conjunction with a dial indicator.

The main table is also mounted on anti-friction slideways. It is equipped with the same type of three-speed control as that provided for the cross-feed, and also with the same system of secondary reference units. The combination, therefore, of the wheelhead slide and the table slide, both freely mounted and provided with accurate and easily settable controls, gives a method of control over a system of rectangular co-ordinates equivalent to that found on the normal jig borer, aided by the anti-friction mounting of both slideways. Fig. 2 shows the table-traverse and cross-feed controls, and the gauge-bar and micrometer settings.

The wheel supporting column has been made in such a way that it is possible to mount on a platform, arranged at the rear of the machine, a " Diaform " pantographic truing arrangement. The bracket upon which this unit is mounted is capable of an independent upward feed movement and a short-length sideways movement towards the wheelhead. With this arrangement, it is possible to wind the wheelhead slide to its rearward position, thus placing the wheel over the pantographically controlled truing diamond or diamonds. With the wheel in this position, a profile copied in reduced ratio from a template attached to the pantographic truing unit can be formed on the underside of the wheel. The wheelhead may then be moved inwards towards the workpiece to transfer the wheel profile to the workpiece. This operation may be performed, and repeated, without disturbing the axial position of the workpiece or removing it from its supports.

Another piece of apparatus which can be provided to ease the task of making profile work is an optical pro-

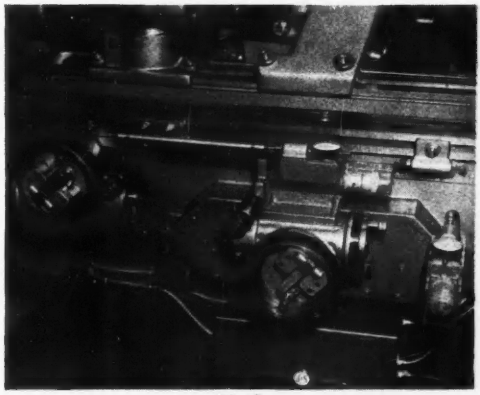
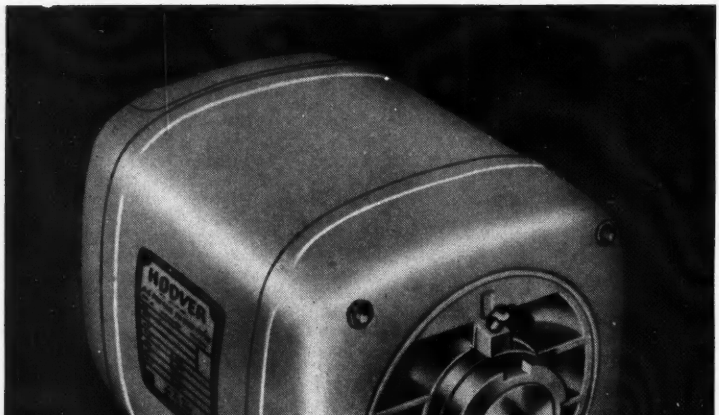


Fig. 2.



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jection unit which is mounted so that the outline of the work can be seen and measured. The optical projection unit at present employed has a 0·3-in. field, with a magnification of ×30, and is provided with various standard graticules. Graticules for any individual form can be supplied. This optical projection unit is mounted upon a slide on top of the wheelhead in such a way that it can easily be moved to inspect either one or the other wheel.

HORIZONTAL CYLINDRICAL-DIE THREAD-ROLLING MACHINE

Easy to set up, simple to operate, and producing uniform, precise threads and forms economically in either large or small quantities, a new two-die type of horizontal cylindrical-die thread-rolling machine, the "Reed B110", has been developed by the Reed Rolled Thread Die Company, of Worcester, Massachusetts. In the new machine (Fig. 1), which has an unusual range and flexibility for a wide variety of applications, control of work dimensions is accomplished by positive adjustment for diameter, length, and taper, approximate setting of the dies being made through an adjustable screw in the movable die head, and final sizing of the thread or form being accomplished accurately by means of a micrometer adjustment.

The moving die is fed into the work by means of a cam-actuated head which pivots to close and open the die gap. This cam mechanism produces a positive and uniform operation, ensuring definite and controlled penetration rates, predetermined length of dwell, and positive duplication of size. This simple mechanical type of cam feed is universal, three standard cams covering the entire range of common thread sizes that can be rolled on the machine. Cams may be modified for any desired constant or varying rate of penetration, while the wide range of standard die and cam speeds, in conjunction with interchangeable standard cams, offers the combinations of cycles of squeeze, dwell, and release usually required for different materials, work, and thread or form specifications.

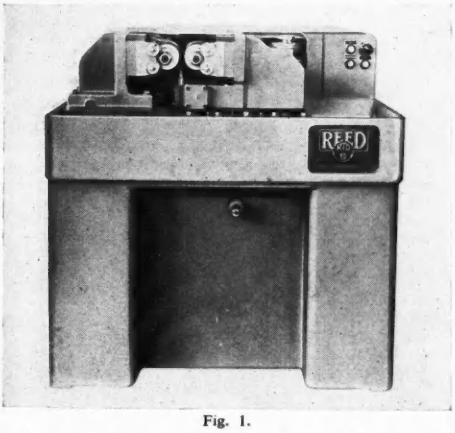

Fig. 1.

A universal cam-actuated work-rest positions the work between the dies. This rest may be set in a fixed position or it may be made to retract automatically during the rolling cycle by means of a simple timing adjustment. A positive, adjustable work-stop governs the position of the thread on the work. Both dies rotate in synchronism. A simple rotary "matching" device offers a quick and positive means of positioning the threads on the dies in correct relation to one another, so that the dies track properly when contacting the blank. A graduated adjusting sleeve provides for accurate matching of the dies, while a matching adjustment chart, mounted on the machine, informs the operator of the correct die-matching settings. The dies always remain in positive match during rolling.

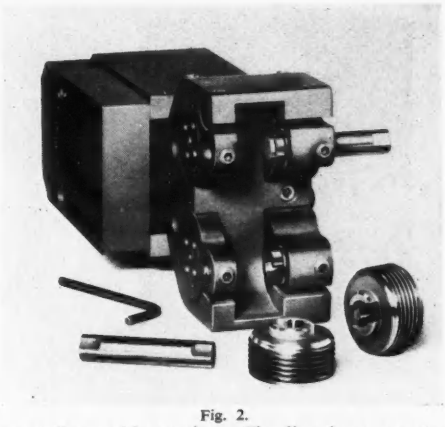

Fig. 2.

The use of highly skilled personnel is not required, owing to the simplicity of operation and ease of change-over from one job to another. Hand operation during set-up is accomplished with a removable hand-crank conveniently located at the front of the machine. A safety switch cuts off all power to the machine when this crank is engaged. Removable or swinging covers and guards protect all moving parts and make all adjustments readily accessible. Cams and dies are easily removed with standard wrenches provided with the machine. Roll spindles are easily removed for rapid changing of the thread rolls, as shown in Fig. 2. Standard machines are furnished for manual loading of parts.

The machine normally functions on a continuous-cycle type of operation, lending itself to convenient and simple control at high production rates. Single-cycle operation can be provided for with special equipment. The machine may be arranged, with special accessories, for through-feed rolling, used for continuous rolling of long threads or successive feeding of short parts through the machine. Extra-heavy die-spindle units are fitted, and the die spindles, moving die head, and cam spindle are equipped with sealed anti-friction bearings.

PAPER CAPACITOR

A new type of paper capacitor, with a performance comparable with that of the more expensive metal-cased types, is announced by the Plessey Co. Ltd., of Ilford, Essex. Stated to represent a considerable advance in the design and performance of paper capacitors and to effect substantial economy in the size and weight of these components, the new capacitor, designated "Plesseal", is suitable for use in domestic radio and tele vision circuits, and industrial electronics equipment.

Designed for long service under conditions of extreme humidity and temperature, the operative temperature range being between −30 and +85°C, these capacitors can be supplied in either standard or logarithmic ranges, extending from 0·005 to 1·0 μF. Normal capacitance tolerance is ± 20%, but capacitors with tolerances of ± 10 or ± 5% can also be supplied. The voltages covered are 150, 250, 350, 500, 750, and 1000 V d.c. at 20°C, but these must be derated by 25% for operation at temperatures over 70°C.

The shape of the unit is roughly elliptical, with a solid cross-section; consequently, the capacitor has a reduced volume and also effects considerable economy in storage space. The component is wound with the outer foil extended to provide an electrostatic screen, and the tinned-copper terminal lugs are inserted simultaneously, producing a non-inductive unit. The lugs are shaped and connected to the foils in a manner which allows the

FLEXBAC pads provide superior finishes in far less time than any other means of sanding

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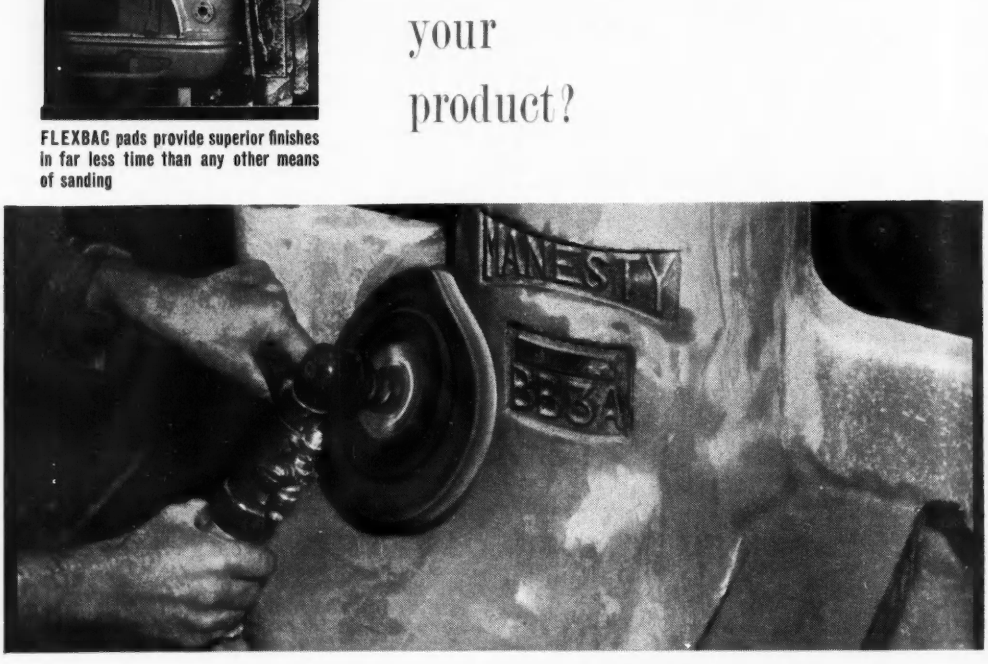
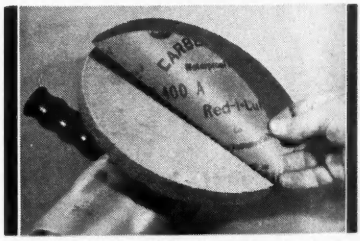


Concave and convex surfaces, complex curves and plane surfaces . . . all are sanded with greater speed and sureness when a 'Flexbac' pad is used. The supple, foam rubber cushion readily conforms to difficult contours, which would ordinarily need sanding by hand



RAPID DISC CHANGES: When the abrasive is worn, the used disc is peeled off, and a new one pressed into position within seconds. The special adhesive can be re-activated when it begins to lose tackiness.

FLEXBACPAD

FOR SUPER-SMOOTH FINISHES – FASTER – ON CONVEX, CONCAVE, AND PLANE SURFACES

A product by **CARBORUNDUM**

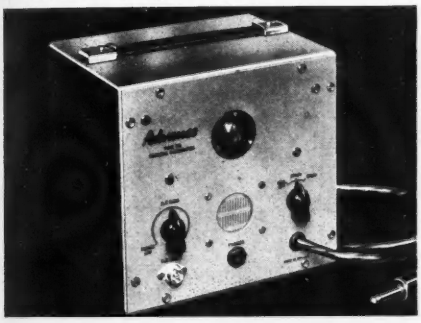
THE CARBORUNDUM COMPANY LIMITED, TRAFFORD PARK, MANCHESTER 17 PHONE: TRAFFORD PARK 2381

contact resistance to be reduced to a minimum. The terminal wire is spot-welded to the lug, which is then folded around it, and the complete assembly is soldered to provide a solid electrical and mechanical joint which forms an excellent, moisture-resistant seal.

Impregnating and coating materials are of similar chemical composition, but with different physical constants. The finishing process, applied after impregnation, is such that each coat provides a key for, and is effectively bonded to, the next, thus producing a homogeneous covering which extends just past the soldered joint and forms a complete seal around the component. A flexible-lacquer final seal entirely envelops the capacitor and assists in completely excluding all moisture from the unit. The average d.c. break-down voltage at normal temperatures is over five times the rated d.c. working voltage, thus ensuring an adequate safety factor, even at elevated temperatures.

CRYSTAL CALIBRATOR

Developed to cater for the need for higher frequency accuracy of test-signal sources, the "Advance" type 74 crystal calibrator announced by Advance Components Limited, of Hainault, Essex, provides facilities for setting accurately a signal, with both visual and aural indication, to multiples of 5 Mcs and 1 Mcs over the frequency range of 1 to 250 Mcs. It may also be used at higher frequencies with reduced sensitivity.

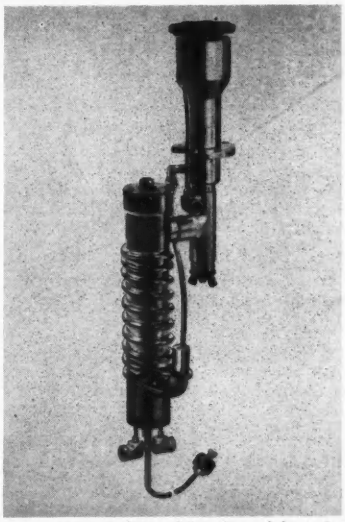


The instrument comprises a 5-Mcs crystal oscillator beating with the unknown signal in the grid circuit of a pentode valve, which functions as a detector and as an optional 1-Mcs oscillator. The resulting beat frequency between the unknown signal and the nearest 5-Mcs (or 1-Mcs) multiple is fed via a low-pass filter and gain control to an audio amplifier. The amplified beat note is then fed to a speaker (or earphones) and to a rectifier circuit. The resulting d.c. output is smoothed and applied to a magic-eye tuning indicator of the twin-sensitivity type, permitting the use of a wider range of acceptable input voltages without recourse to adjustment of the gain control. At zero beat the audio-amplifier response falls to zero, so that the eye opens when exact resonance is established. This feature permits higher precision than that normally obtainable with aural indicators.

The instrument may also be used for receiver calibration, but, as this application is not a primary design objective, it will depend greatly on receiver characteristics, e.g., input impedance, sensitivity, signal-to-noise ratio.

HIGH-VACUUM PUMP-AND-PORT ASSEMBLY

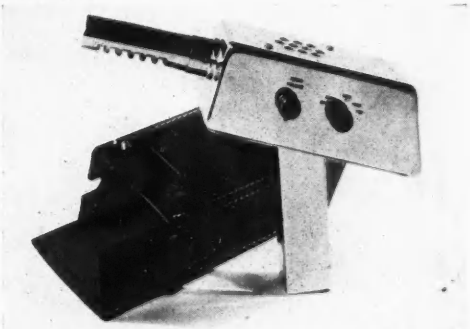
A new high-vacuum pump-and-port assembly is announced by the Rochester Division of Consolidated Electrodynamics Corporation. This stainless-steel unit, designated Type 3116-03, should find wide use in the evacuation of cathode-ray tubes, and should prove particularly useful for stationary and in-line evacuation systems for both black-and-white and colour-television tubes. It has a pumping speed of 5 litres/sec. at the port opening, with an ultimate pressure of 2×10^{-6} mm Hg.



The port accommodates either $\frac{3}{8}$- or $\frac{1}{2}$-in. tubulations, and is water-cooled to protect the sealing gasket during oven bake-out. Since the port is connected at a right angle to the pump, broken glass cannot enter the pump-jet area. A trap is provided at the base of the port for easy cleaning. An important feature of the pump-and-port assembly is the rapid two-minute cool-down of the pump fluid, effected by internal boiler quench coils. The small boiler requires a minimum of pump fluid and is heated by a cartridge-type heater for maximum heat transfer.

TRANSISTORIZED GEIGER COUNTER

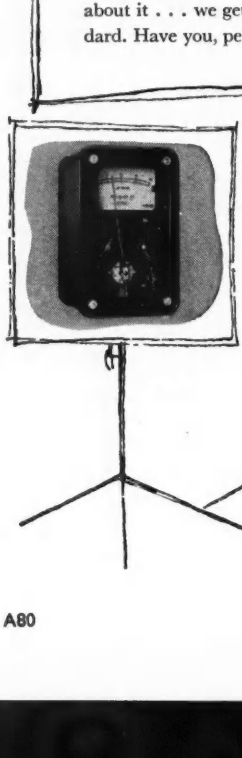
Stated to be the first low-cost professional Geiger counter to operate on a battery pack of two flashlight cells, the "Transisto-Gun", announced by the Radiac Company, of New York, features transistorization of the complete circuit, including the power supply, with the consequent elimination of large and costly "B" batteries and valves.



The "Transisto-Gun" contains a built-in loudspeaker driven by a transistor audio-amplifier circuit, thus doing away with the need to wear earphones. An external volume control permits adjustment of the click volume to any desired level, while a panel meter with three ranges is provided for additional indication of radioactivity, and for comparative radiometric assay. An important characteristic is the extremely low current drain, which means that the two inexpensive flashlight cells, which are the entire battery complement of the instrument, will last for hundreds of hours of use.

What's the score?

An unusual looking baton? Certainly; and a most sensitive one. It is, in fact, the needle of an Austinlite marginal relay, a piece of equipment much in demand wherever very small variations of voltage or current are used for control purposes. We designed it in the first place for control equipment of our own, because nothing quite sensitive, and at the same time robust, enough was available. Now it is standard equipment. That is how most Austinlite equipment originates: we design something for an unusual job and build it. Other people hear about it . . . we get enquiries . . . and so it becomes standard. Have you, perhaps, a non-standard enquiry to make?



Austinlite **EQUIPMENT**

Tailor-made by STONE-CHANCE LTD.

(*The makers of Sumo Pumps and Stone-Chance Lighthouses*)

28 ST. JAMES'S SQUARE, LONDON, S.W.1. TEL. TRAFALGAR 1954

NEWS OF THE MONTH

PERSONAL

Mr. J. Bell, who for some time has been Assistant Branch Manager of Simms Motor Units Ltd., at Glasgow, took up his appointment as Branch Manager at Cardiff with effect from 1st November.

Mr. A. Bowlt has been appointed Chief Buyer of Guest Keen Iron & Steel Company Limited, in succession to the late Mr. A. S. Davies, M.B.E.

Mr. James B. Longmuir, who has represented Hegator Pumps & Compressors Ltd., 43 Berkeley Square, London, W.1, in Scotland for the past six years, has been appointed to the newly created post of Scottish Regional Manager.

Chaseside Engineering Company Ltd. announce the appointment of **Mr. R. B. Long** as their Export Sales Manager. He has previously served as a District Manager in Venezuela of Ford International, Detroit, U.S.A., Overseas Representative for Latin America of Ford Motor Company, Dagenham, and in an Executive appointment with the Standard Motor Company in Europe.

Mr. J. H. Hutchinson, A.M.I. Mech.E., has been appointed Assistant Engineering Sales Manager by The Hymatic Engineering Co. Ltd. of Redditch, Worcs.

The A.E.I. Lamp and Lighting Company Limited announces that as **Mr. V. C. H. Creer, M.A.,** has ceased to be Joint Managing Director, **Mr. S. R. Eade, M.I.E.E.,** has been appointed sole Managing Director and **Mr. J. Clement, B.Sc.,** Sales Director.

Welding Supervision Ltd. announce that the present manager of the company, **Mr. C. C. Bates,** has been appointed to the Board of Directors. In addition to his administrative duties with Welding Supervision Ltd., Mr. Bates will now be concerned with the welding activities of the parent company, Costain-John Brown Ltd.

Mr. W. Latta, Sales Director of Rhodes, Brydon & Youatt Ltd., of Stockport, has flown to South Africa for two months to promote increased sales of the Company's wide range of centrifugal pumps, and to appoint agents. He will be visiting Johannesburg, Durban, East London, Port Elizabeth, Cape Town, Bulawayo and Salisbury, returning by sea on 11th January, 1957.

Following the recent announcement of the appointment of **Mr. Edward Turner** as Managing Director of the Automotive Division of the Birmingham Small Arms Group, a further appointment has now been made—that of **Mr. Arthur Griffiths, O.B.E., M.I.P.E.,** as Director and General Manager of The Daimler Company Limited. Mr. Griffiths will operate from the Daimler factory, Radford Works, Coventry, where cars, buses, diesel engines and other products are manufactured.

Metropolitan-Vickers Electrical Export Co. Ltd. announces that on 12th August, 1956, **Mr. H. F. Bibby, B.Sc.Tech., A.M.I.E.E., A.M.I.Mech.E.,** formerly Manager, American Division, was appointed Assistant General Manager. He was succeeded as Manager, American Division, by **Mr. C. H. de Nordwall, M.I.E.E.** Mr. de Nordwall retains his seat on the Board of Metrovick do Brasil (Electricidade) Ltda.

Mr. Clifford E. Adams, who has been Accounting Division Manager of Caterpillar Tractor Co. Ltd. for the past four and a half years, has been appointed Chief Accountant of the Desford factory.

Mr. A. E. Potter of Expandite Limited, the well-known manufacturers of Jointing Materials and Sealing Compounds, left on Tuesday, 20th November, 1956, for Australia. The main purpose of his visit is to establish an Australian subsidiary and make arrangements for local manufacture. This step has become necessary due to the increasing demand for the Company's products and the curtailment of imports into Australia. During the visit overseas, Mr. Potter will also deal with the Company's interests in New Zealand and United States of America.

Sentinel (Shrewsbury) Limited announce that **Mr. J. D. Pearson, J.P., B.Sc.(Eng.), Wh.Sc.** and **Mr. W. T. Gill, C.A.,** have joined the Board of the Company. Mr. Pearson is Deputy Chairman and Chief Executive and Mr. W. T. Gill is Financial Director of Rolls-Royce Limited.

The Power-Gas Corporation Ltd., Stockton-on-Tees, has just announced the appointment of two Divisional Directors who will be responsible for the development of the company's trade within special fields. **Mr. P. M. K. Embling, B.Sc.(Eng.)** was appointed manager of the Chemical Plant Division of The Power-Gas Corporation Ltd. in 1955 and he now becomes Divisional Director responsible for that division. **Mr. D. R. Brown** was appointed manager of the Blast Furnace Division of Ashmore, Benson, Pease & Co. in 1955 and as divisional director he is now responsible for the promotion and development of blast furnace and ancillary plant marketed by the company.

CHAPMAN & HALL

Just Published

MAINTENANCE OF HIGH-SPEED DIESEL ENGINES

A Practical Handbook for Diesel Engine Fleet Owners, Maintenance Engineers, Drivers and Mechanics

by

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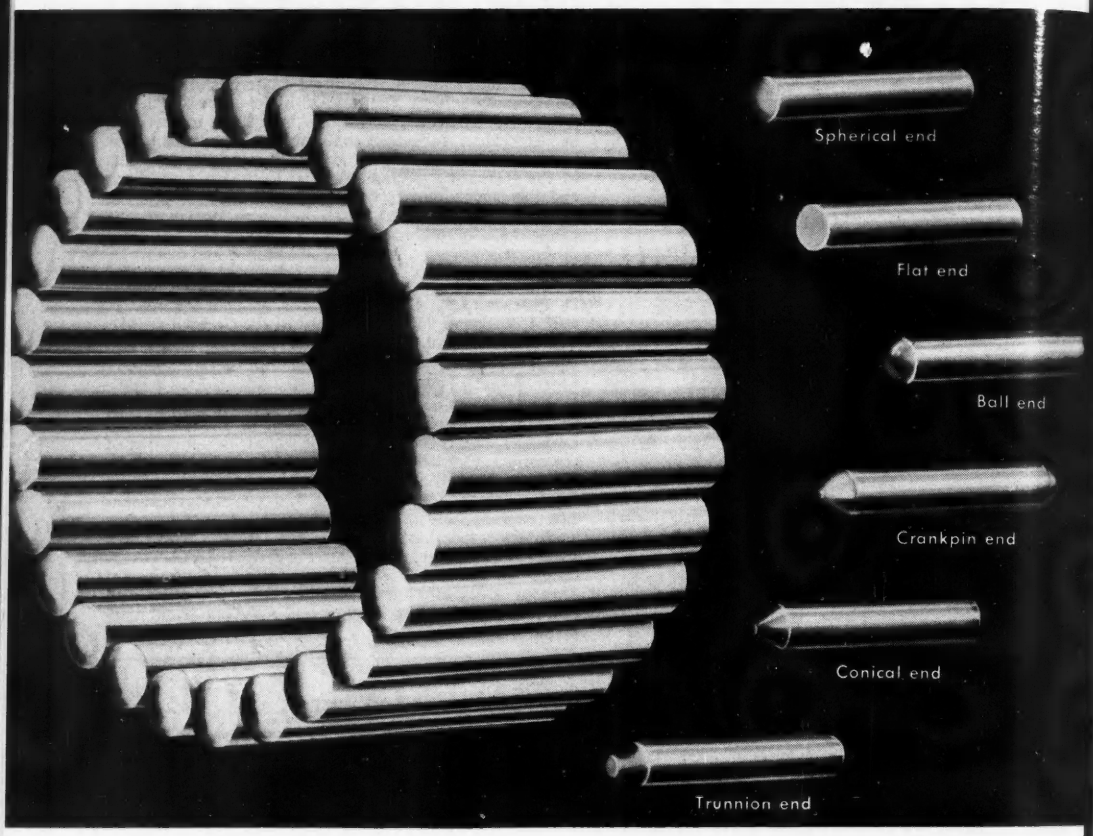
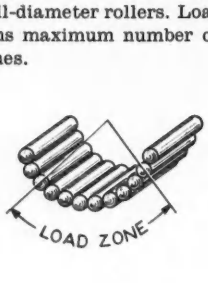
TORRINGTON NEEDLE ROLLERS
for the ultimate in load capacity at low cos

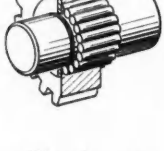


High radial capacity in minimum space is provided by full complement of small-diameter rollers. Load zone contains maximum number of contact lines.



High carbon chrome steel is carefully hardened, ground and lapped to make each Needle Roller a precision part for long-life performance.

Close tolerances on Needle Rollers are assured by stringent quality controls. Standard OD tolerance is .0002". Tolerance on length dimension depends on end formation.



Mounted without races between hardened shaft and hardened housing (RC-60 recommended), Needle Rollers allow largest possible shaft diameters.

Fine finish contributes to efficien anti-friction performance. Needl Rollers are usually polished to 4 rms finish.

Good operating results with Needl Rollers require careful design of ma ing parts furnished by the user.

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TORRINGTON *NEEDLE* BEARINGS

ΦE

NOW AVAILABLE FROM OUR ENGLISH FACTO

BUSINESS NOTES

A new Branch Office has been opened in Birmingham by **Square D Limited,** to provide efficient " on-the-spot " technical representation for Square D Electric Control Gear in the Midlands industrial region. In charge of the new office is Mr. A. S. Paice, Area Manager for the Midlands. Also operating from the Birmingham Office will be Mr. K. W. Liller, who has been appointed a Field Engineer for the area. The new offices are at 72a Queen's College Chambers, Paradise Street, Birmingham ; telephone number MIDland 4212.

The opening of northern area offices in Manchester by Square D Limited means that field engineering coverage for the whole of England and Wales for the sale of Square D electrical control gear has been achieved within twelve months of the company's formation. The new offices are at 4 Minshull Street, Manchester 1 : telephone number CENtral 9757. Mr. W. A. King-Smith, who joined Square D at its inception, has been appointed Northern Area Manager, and he will be assisted by Mr. C. Robinson who is the new Field Engineer.

Gibbons Brothers Limited, a subsidiary of Gibbons (Dudley) Limited, announces that it has acquired an interest in **Metallurgical Oxygen Processes Limited,** of Granite House, Cannon Street, London, which has developed processes for the heating of metals without scale or oxidation. The present directors, Dr. A. G. E. Robiette and Mr. J. Miles, remain on the Board. The patented processes controlled by Metallurgical Oxygen Processes involve the use of oxygen and are designed to effect considerable economies in the iron and steel industry, especially in the rolling, forging and extrusion of steel. Licences have already been granted in the U.S., Canada, France, Belgium, Austria and other countries.

British Tyre & Rubber Co. Ltd. announces that it is planning to expand its operations at Leyland, Lancashire, and has purchased a neighbouring site of 32 acres at Farington. The Company has received Board of Trade approval to erect manufacturing buildings in the area and permission to develop the Farington site has been granted by the Preston R.D.C. and the Lancashire County Council. Expanded manufacturing facilities for a number of the Company's specialized Industrial Rubber products will be installed on this new site and these plants are expected to be operating early in 1958. It is the intention to make the site the local headquarters of the Company's manufacturing operations in Lancashire. The cost of the first stage of this new factory development will be approximately £2,000,000. Pending the erection and equipment of the new factory, the Company is faced with the urgent necessity to provide additional manufacturing space for its Industrial Rubber products. Having regard to the declining economic importance of tyres in relation to the business of the BTR Group as a whole, the Board has decided that the interests of the Company will best be served by ceasing the manufacture of Car, Giant and Cycle Tyres, and arrangements have been made accordingly.

To encourage and develop still further the advancement of the Company, **Monks & Crane Limited** announced on 2nd November, 1956, certain changes on the Board of Directors : Mr. B. C. Kirk, J.P., F.C.A., and Mr. E. C. Martin relinquished their positions as Chairman and Joint Managing Director respectively of the Company as from that date. The new appointments are now that Mr. D. W. Thomas is appointed as Chairman and Mr. V. G. Eyre is appointed as Managing Director. The present Board now comprises Mr. D. W. Thomas, Chairman, Mr. V. G. Eyre, Managing Director, Mr. A. H. Barton, Director. It was unanimously agreed that this reorganisation of the Company is in the best interests of all concerned and will facilitate further progress.

Bennis Combustion Limited, Little Hulton, Walkden, Manchester, announce that as from the 1st November, 1956, their sole Representatives for Scotland will be **Engineering Agencies,** Atholl Works, 190 Rumblingwell, Dunfermline (Telephone: Dunfermline 1677 (2 lines)—after office hours Dunfermline 249 and 1339). Mr. J. P. Gibb and Mr. J. Beveridge will be actively and solely engaged in this representation which is for the whole range of Bennis products, including complete Steam Generating Plant, Mechanical Stokers, Water Tube Boilers, Oil Burning Equipment, Mechanical Handling Plant, etc. A full range of Bennis spares will be carried in the newly formed Spares Stores at Atholl Works.

Remington Rand Limited announce the formation of an Electronics Division. This has been done, the Company states, because of the immense potential in the field of electronic office equipment and in consideration of the current interest in the use of this equipment in the United Kingdom. Heading the new division is Mr. C. W. Elliott as its National Sales Manager.

Matthews & Yates Ltd., Manufacturers of Cyclone Fans and Fan Equipment announce that they have transferred their Birmingham Office to larger premises at County Chambers, Corporation Street, Birmingham 2. Telephone No. Central 1089 (2 lines).

A new office block has recently been completed and occupied by the **Wickman Wimet Division** at their main works in Torrington Avenue, Coventry. Of reinforced concrete construction, the new building provides about 10,000 square feet of administrative office space on two floors, and accommodates staff displaced from the main building through expansion in manufacturing capacity, and additional personnel to facilitate the handling of an increasing volume of daily orders.

The members of the Hacksaw Trade Section and the High Speed Steel Hacksaw Trade Section, of **The British Hacksaw Makers' Association** agreed at their recent Annual General Meetings that, in the national interest and in furtherance of export trade, the prices for their products would not be increased before the 31st March, 1957, subject to no unexpected and exceptional circumstances arising beyond members' control and due to the international situation.

To ensure adequate service to customers and deal with the commitments of a rapidly expanding market for Mirrlees and National marine engines, **The Brush Group Ltd.** will conduct its heavy marine engine business as from 1st November under the auspices of two separate companies to be known as **Associated British Oil Engines Marine (Mirrlees) Ltd.** and **Associated British Oil Engines Marine (National) Ltd.,** respectively. This arrangement has involved regrouping the sales force into individual units dealing separately with Mirrlees and National sales, which will permit closer personal contact between customer and Group marine representation, and in addition will offer the advantages of more specialized selling as related to owners' specific technical problems.

A new company, responsible for the sale in British Columbia, the Yukon, Alberta and Saskatchewan, of all Brush Group products manufactured in the U.K., has been incorporated in Vancouver under the title **Brush Group Sales (Western Canada) Ltd.** It has been formed to enable the executives of **Vivian Diesels and Munitions Ltd.,** the Group's manufacturing subsidiary in Vancouver to concentrate on the engineering business of that company. The directors of Brush Group Sales (Western Canada) Ltd. are Mr. D. Dewar (chairman) and Mr. G. E. Hirst (managing). The responsibilities of Brush Aboe (Canada) Ltd., the Group's sales company in Toronto covering Eastern Canada, are unchanged.

LANGITE

jointing material resists oils and spirits.

Used on practically every motor vehicle manufactured in this country; for more than 30 years it has also been used extensively by the electrical, oil, petroleum, aircraft and other industries.

CORK MANUFACTURING COMPANY LTD., SOUTH CHINGFORD, LONDON, E.4
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NEOLANGITE

A range of synthetic-rubber-bonded cork jointing materials, having the characteristic resilience of Langite but greater mechanical strength and recovery after compression. Used extensively on transformers, motor vehicles, aircraft etc.

CHINGFORD CORK 'JOINTING' MATERIAL

For less critical applications, cost may be saved by the use of this material, made alongside Langite but to a less exacting specification. All other types of non-metallic seals, compressed asbestos fibre, impregnated paper etc. can be supplied.

A new Craft Training School for apprentices employed by **British Oxygen Engineering Limited** was opened at Angel Road, Edmonton, on Thursday, 15th November, by Mr. Robert Carr, M.P., the Parliamentary Secretary to the Ministry of Labour. The building comprises a machine shop, fitting sections and a lecture room, and the shops are laid out to enable the wide range of work in Plant, Industrial, Medical and Aircraft fields to be covered.

Mullard Limited will shortly be moving into their new headquarters at Torrington Place, W.C.1. For some years now several departments of the organization have been temporarily accommodated in a number of separate premises and the move will eventually bring all departments under one roof. Customers of the company will benefit from the centralization of the various departments which serve them, and those who visit the new premises will find complete technical and information services available. In addition there will be extensive showrooms, a demonstration centre and cinema. The move will take place in the near future and eventually all head office staff will be accommodated in this new building.

It is announced that Nevelin Electric Co. Ltd., and Lancashire Dynamo Switchgear Ltd. will now be known as **Lancashire Dynamo Nevelin Ltd.**

From the 3rd of December, 1956, the **British Steel Castings Research Association** will move from their Bromsgrove Lodge address to its new Laboratories at East Bank Road, Sheffield, 2. Tel.: Sheffield 28647.

More than 10,000 industrialists are expected to visit the "**Gas At Work In Industry**" **exhibition**—the first of its kind to be held in London—at the Royal Horticultural Hall, from January 22 to February 2, 1957. Over 70 manufacturers have combined in this unique exhibition to show the manifold ways in which gas plays its part in the world of industry. Exhibits on show will range from gas-fired water and space heaters, to highly complex pieces of equipment for shell moulding, tool cutting and flame hardening—many of them electronically controlled. It will be a "live" show, with more than half the appliances displaying, through demonstrations, the work they normally do in the factory and workshop.

Since opening their Branch Offices in South Africa and Australia, the sale of the products of **Mono Pumps Limited** has grown sufficiently to warrant an extension of their activities in those countries. In South Africa developments have justified the formation of an overseas subsidiary and a company to be known as Mono Pumps (Africa) (Pty) Limited has now been formed to foster interest throughout the continent of Africa. The Directors of this new company are: Chairman, H. B. Hichens, M.B.E., B.A.Hons.(Cantab.), M.I.Mech.E. ; Managing Director, A. Taylor ; Directors, A. W. Gregory, J.P., R. R. Kennan, A.M.I.Mech.E., (Alternate A. R. McCall). This Company has purchased a modern factory and new offices in the Johannesburg district and will follow an independent line of developments suited to the circumstances and peculiarities of the area covered by the Company. The Australian Branch has also established a Works in a suburb of Melbourne for the assembly and manufacture of certain parts of the Mono Pump so that the requirements of the Australian market are more adequately served.

British Insulated Callender's Cables Ltd. announce that as from December 10th their Tunbridge Wells office will be transferred to Water Lane, Maidstone. Telephone number : Maidstone 51113–4. The greater storage accommodation available at the new address will enable a wider range of products to be carried for immediate delivery from stock.

The extensive range of "FICEP" Shearing machines and Friction Screw Presses of Italian manufacture is now being introduced by **Thos. W. Ward Limited, Albion Works, Sheffield,** who have recently been appointed sole distributors in the United Kingdom. This includes Billet Shears, Hot and Cold Bar Shears, Universal Punching and Shearing machines, Alligator Shears and Friction Screw Presses up to 360 tons capacity.

An impressive demonstration of the new **Atlas Copco Ltd.** Cobra motor drill was given on Monday, 12th November. Weighing only 53 lb., two of these machines were flown to South Bank by helicopter with their operators who demonstrated the high degree of efficiency and portability essential for drilling in remote and difficult areas. The maximum drilling depth is 13 ft. and the drill can be operated in any directional position. The easy removal of three small parts converts the Cobra drill to a breaker.

Ransome and Marles Bearing Co. Ltd., of Newark, who have been manufacturing bearings for nearly half a century, claim to have built up a designation system which they believe makes a considerable effort to describe the bearings involved. Inevitably the system has its complications for the more obscure types, but the user who is unfamiliar with bearings should find it a helpful guide. Each designation consists of some letters and a number. Whether it is an inch or metric size, the number is always the actual bore diameter of the bearing. Where confusion might occur between the sizes, inch bearings carry the suffix "E" for "English". The designation letters are the initial letters of the words used to describe the particular bearing concerned. Under this system the basic designation is still used for bearings with special features but this is preceded by a number (1/, 2/, 3/, etc.) which denotes a variant.

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. . . provide for the silent transmission of power. They cushion drive and obviate the necessity for lubrication, adjustment or maintenance. Produced in a variety of sizes and styles to suit popular requirements.

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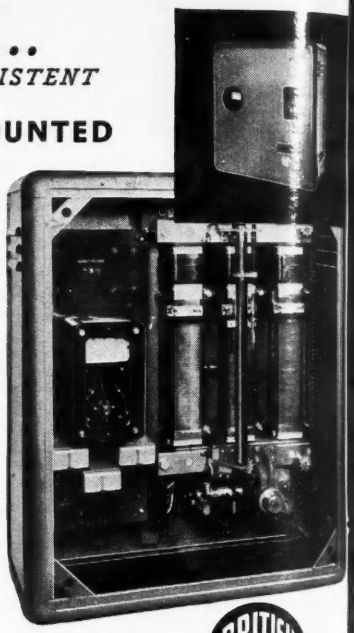
AUTOMATIC VOLTAGE REGULATORS



Consistent supply voltage is essential to industry for manufacturing processes and to extend the life of important electrical plant.
B.P.T. automatic voltage regulators eliminate all variations in supply voltage, regardless of variations in frequency, load and load power factor.
The following is a list of the standard wall mounted, air cooled regulators which compensate for variations of supply of ±15%. They are available with early delivery.

MODEL	Current Amps.	L Ins.	W Ins.	H Ins.	Weight lbs.
SINGLE PHASE, 200/250 volts, 50/60 cycles.					
A-1CW	12.5	18½	10½	28½	210
A-2CW	25	18½	10½	33½	260
A-4NXW*	45	18½	10½	40½	310
A-5NXW*	70	18½	10½	43½	390
THREE PHASE, 380/440 volts, 50/60 cycles.					
A-13GW	7.5	22½	10½	26½	200
A-13HW*	10	22½	10½	26½	200
A-23GW	12.5	22½	10½	30½	250

** These models have a compensation range of ±10%.*

Other standard Regavolt models are air cooled, cubicle type in ratings up to 100 amps and oil immersed types up to 240 amps.
Full details will be gladly supplied on request to :

Automatic Regulators are available at prices below £100

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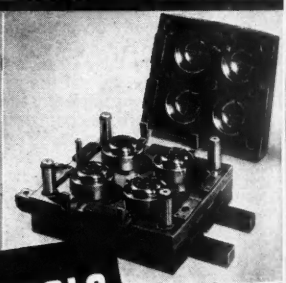
Designers and Manufacturers of



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CONTRACTS

A dollar order for Canadian agricultural machinery components has been won by a British firm against keen American and Canadian competition. **Geo. Salter & Co. Ltd.**, of West Bromwich, announce that the **Massey-Harris-Ferguson Company** of Toronto, has ordered a large quantity of roller bearings worth 30,000 dollars. Delivery is to be completed by January 1957 on these initial orders for their 1957 production programme. Salter bearings have been used extensively for some years by the British M-H-F organization, but this initial order from Canada is regarded as a considerable achievement. Competition from the United States and Canada was extremely keen, and Salters have only been able to meet this on quality and price by employing the most up-to-date machine tools and production techniques.

An interesting contract valued at 150,000 Canadian dollars has been obtained by **Tangyes of Canada Limited**, the Canadian Subsidiary Company of the British firm of Tangyes Limited, Smethwick, for Hydraulic Equipment to be manufactured in England. The equipment will be used to lift 14,000 tons of the Jacques Cartier Bridge spanning the St. Lawrence River to give an additional 60 ft clearance for shipping passing below the bridge. Traffic over the bridge is not to be interrupted.

An important contract, the British share of which is in excess of £1,600,000, has recently been placed by the **Portuguese Administration, Administração Geral Dos Correios Telégrafos E Telefones,** (CTT) with **Standard Telephones and Cables Limited** for the provision of a comprehensive telecommunications network between Lisbon and Oporto and other localities in the presidency. This far-reaching project, jointly planned by engineers of the CTT and the " Standard " organization, embraces the supply and installation of equipment to provide telephone, telegraph and broadcast circuits and the provision of the necessary cable system. Manufacture of the equipment will be shared between Standard Telephones and Cables Limited and their associates Standard Electrica Lisbon, and will proceed concurrently in Great Britain and Portugal.

Rhodesia Railways has ordered a further twelve 2000 hp diesel electric locomotives from **The English Electric Company Limited.** This repeat order follows shortly after the completion by the company of the original contract for twenty-three locomotives of the same design and power. They are the most powerful diesel electric locomotives ever built for a narrow gauge railway.

Bairds & Scottish Steel Limited has placed an order with **The General Electric Co. Ltd.** for a high-pressure turbo-blower to be installed at Gartsherrie Iron Works, Coatbridge, Lanarkshire. The machine is a turbine-driven centrifugal blower capable of delivering a maximum volume of 60,000 cu ft of free air a minute at N.T.P. against a pressure of 16 psig. This plant, which will be manufactured at the Fraser & Chalmers Engineering Works of the G.E.C. is a duplicate of one already installed at the Gartsherrie Iron Works and commissioned in December 1955.

Babcock & Wilcox Limited have received an order for the construction of the reactor vessel for Canada's first nuclear power plant. This is for the N.P.D. (Nuclear Power Demonstration) project, which will also be the first nuclear power plant in the Commonwealth outside Great Britain. The Canadian General Electric Company are the main contractors. The vessel is approximately 12 ft in diameter and 35 ft high. It is designed for a pressure of 1200 lb/sq in., and is 5 in. thick, increasing in places to 6½ in. It weighs 210 tons, of which 70 tons is in the head.

Classified Advertisements

The rate for all classified advertisements is 6d. per word ; in bold print 9d. per word ; minimum order 6s. Box-number advertisements 1s. extra. Instructions, together with remittance, must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

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Heavy Engineering Company has vacancies for

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with experience of large scale site erection required to be responsible for the installation of an integrated steelworks to be built in West Bengal in the period 1957–1961. Immediate employment in England offered to suitable applicants pending movement to India when work has progressed sufficiently.

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Canada's inland deep water port.
Wallaceburg's Population—7887.
Area—1100 acres including river.

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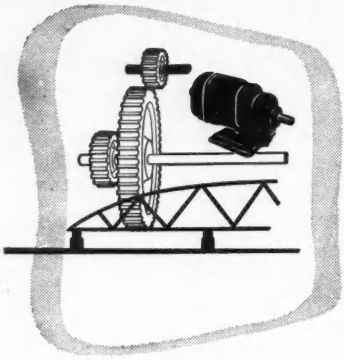

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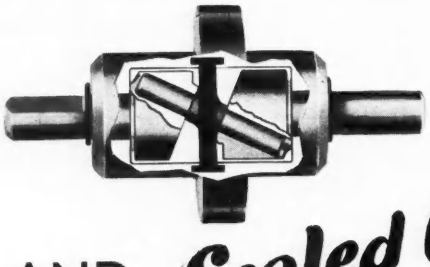

Ensuring positive hermetic sealing, this bulkhead coupling is manufactured with $\frac{1}{8}$" to $1\frac{1}{2}$" diameter shafts. There is no alternative to this form of drive for positive sealing, particularly on pressurised equipment.

AND *Sealed Control Knobs*

Suitable for panel mounting. These sealed knobs, easily fixed to any components, ensure positive sealing of the equipment on which they are used.

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BOOKS RECEIVED

Jig and Fixture Design. By P. S. Houghton, A.M.I.Mech.E. 266 pp. 172 illustrations. Publishers: Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price: 36/-.

There is undoubtedly a progressive increase in the demand for equipment which can be readily attached to the standard range of machine tools, thus increasing the potentialities of any given factory. This book covers the subject of jigs and fixtures comprehensively in its nineteen chapters, which range from Planning of Production of Materials, Design Notes and Standard Clamping Methods, Indexing Mechanisms, Drill Jigs, Drilling, Tapping, Boring, etc. to Air-Operated Equipment, Dimensional Standards, and Motion Study and Design.

Catering well for the needs of students, this authoritative book should also prove useful in the engineering industry in promoting a better appreciation of problems and developments in the design of jigs, fixtures, and special equipment.

Theory and Practice of Lubrication for Engineers. By Dudley D. Fuller. 446 pp., 234 illustrations. Publishers: John Wiley & Sons, Inc., New York, and Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price: 84/-.

This interesting book, the first to give balanced treatment to theory and practice in lubrication, and to offer a complete treatment in English of hydrodynamic theory, with emphasis on the point of view of engineers, not only presents a solid foundation in the theory of lubrication but also applies to a wide range of lubrication problems. Many bearing designs are given, including those for machine tools, turbines, generators, large motors, rolling mills, ball mills, and centrifuges.

For the benefit of those engaged in research, Professor Fuller has deliberately incorporated considerable material that should kindle the imagination and lead to further study. In addition, direct references are made to outstanding examples of recent research in lubrication, while the techniques used and the results achieved are included in discussions.

Legal Problems in Engineering. By Melvin Nord, Dr. Eng. Sc., LL.B. 402 pages. Publishers: John Wiley & Sons, Inc., New York, and Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price: 60/-.

As Dr. Nord indicates in his preface, although engineers do not need to know enough law to be able to do without lawyers, they need to know enough to avoid legal problems before they have a chance to arise and to work effectively with lawyers after they have arisen. This book has been written with this object in view and admirably accomplishes its purpose. Thus, it is broader in its scope and coverage than any other comparable work, dealing with almost every legal subject with any bearing on engineering and treating each topic thoroughly.

A special feature is the treatment of case material. Instead of following the usual voluminous "casebook" approach, the author uses cases to illustrate discussions and to point out the legal problems which may be encountered in given circumstances, these being presented in a condensed form which eliminates unnecessary side-issues. Furthermore, there is a minimum of that peculiarly irritating, frustrating, illogical, pointless, ambiguous prolixity known as "legal jargon", rendering the treatment all the more valuable to the non-lawyer seeking a concise, reliable survey of the field.

An Encyclopaedia of the Iron & Steel Industry. Compiled by A. K. Osborne, A.Met. 574 pp., 26 illustrations. Publishers: The Technical Press Ltd., 1 Justice Walk, London, S.W.3. Price: 90/-.

With the enormous increase in scope of the technical background of the iron and steel industry during the past forty years or so, and the corresponding increase in the amount of relevant technical literature available, it is not surprising that the unique terminology of the industry itself has been increasing similarly. There can be no doubt, then, that this new encyclopaedia, compiled by A. K. Osborne, technical librarian and information officer of the Brown-Firth Research Laboratories, Sheffield, and representing a recently revised presentation of material collected over more than twenty-five years, fulfils a definite need for those interested in, but not necessarily specializing in, this field of metallurgical practice.

This useful book, therefore, admirably succeeds in its purpose of providing a concise description of the materials, plant, tools, and processes used in the iron and steel industry, and in those industries closely related to it, from the preparation of the ore down to the finished product. In addition, the book, which is intended purely as a work of reference and not in any sense as a textbook, defines the technical terms employed in the industry and includes a useful series of appendices containing references, conversion tables, properties of steels, signs and symbols, and a list of scientific, technical, and trade societies and other bodies related to the iron and steel industry.

The "Speedicut" Manual of Screw Thread Tools. 321 pp., 110 illustrations. Published by Firth Brown Tools Ltd., Speedicut Works, Carlisle Street East, Sheffield, 4. Price: 25/-.

Providing an informative and practical guide to those whose technical knowledge of screw-thread too's is limited, this authoritative and comprehensive manual is at the same time a useful reference to those with greater experience. With its detailed lists of tapping drill sizes, and notes on lubrication, speeds, and the causes of and remedies for tap faults and failures in operation, it will undoubtedly be especially useful in the workshop.

Whilst the book deals with various methods of thread production, the main emphasis is on screwing taps. Up-to-date tap and screw-thread nomenclature and definitions are given, and many different types of taps in general use are described. In addition, the factors involved in their design and maintenance are explained, together with information of great value in assisting in the selection of the most suitable kind for a wide range of materials.

LATEST INDUSTRIAL LITERATURE

1. Soldering Aluminium Cables. This 83-page handbook provides notes on the fundamentals of the problems of soldering aluminium and detailed instructions on the methods of making all normal joints. The instructions have been based on the procedures generally used in this country together with the methods derived from the rather greater experience available overseas.

The book is profusely illustrated and has been written as a practical guide for engineers. The appendix contains a number of useful tables including Supplies of Essential Materials and Current Rating Tables for Aluminium Cables.

2. Air Cylinders and Control Valves. Details are provided in two illustrated 8-page technical brochures of a new series of pneumatic products. The Air Cylinders are detailed in a number of sizes and a variety of stroke lengths for each type. They are available for piston operation parallel to the mounting surface, for pivoted motion of the cylinder and for piston operation through the mounting surface.

Three types of Air Control Valves for use with the Cylinders are described. The hand operated 4-way Rotor Type Disc Valves permit any port to be used for the intake while a detent-located neutral position closes off the ports thus allowing inching action. The basic 4-way Balanced Poppet Type Valves are shown for hand, foot, pilot or solenoid operation. Automatic timing with a simple screw-driver control is an optional facility provided with the 2- and 3-way Pilot Operated Valves giving a wide time-range with a fully or semi-automatic controlled action.

3. Flexible Tubing and Hoses. Produced as a sectioned brochure this publication of 123 pages covers an extensive range of flexibles in various materials, and is designed for the inclusion of subsequent additional sections. The existing brochure details types made of rubber, plastic and metal in addition to composite types and special versions for specific requirements. If required these sections are individually available. Each section contains considerable technical data upon which the choice of a suitable type can be made, while the care and maintenance precautions are aptly illustrated.

4. Belting—The Manufacture and Treatment. Written as a practical guide to the methods recommended to ensure maximum efficiency and life, this 24-page booklet covers leather, woven, Balata, rubber, and driving rope types. Brief notes are provided giving the basic method of manufacture and outlining their advantages and limitations. The necessity for belt dressing is discussed in general together with the recommended methods of treatment. A number of useful hints are provided on belt repair and maintenance while technical details are contained in 3 reference tables.

5. Machine Tool Lubrication. The machine tools of to-day are both intricate and costly, and their correct lubrication, being of vital importance, is recognized as a matter for experts. An up-to-date and authoritative work, dealing comprehensively with the subject is now available. This copiously illustrated 96-page book commences with a brief history of the machine tool industry, followed by a detailed examination of the fundamentals of friction and lubrication. General design features of modern machine tools are discussed at length in another chapter, and typical tools—lathes, milling machines, planers and shapers, etc., are then reviewed under separate headings, their construction, operation and lubrication being fully covered. Finally, the book gives details of a scheme for efficient factory lubrication and advice on oil storage equipment, mechanical lubricators, and production oils. It is believed that this publication will be of interest to everyone connected with the machine tool industry.

6. Ultrasonic Metal Cleaning. An illustrated leaflet describes a range of automatic and hand operated cleaning machines using ultrasonic agitation of the cleaning solvent at a frequency between 25 kc/s and 1 Mc/s, the power for the sound head being derived from valve oscillators providing an output ranging from 200 W to 6·5 kW. The ultrasonic cleaning operation is carried out in conjunction with a vacuum developed to eliminate air pockets which may form.

7. Machine Tools. A wide range of British and Continental machine tools are illustrated and described in brief essential technical details in this 20-page loose-leaf illustrated catalogue. Many types of cutting machines are included together with presses, engraving, polishing and brazing machines. Marking, optical dividing, induction hardening, pressure die casting, balancing and plastic moulding machines are also described.

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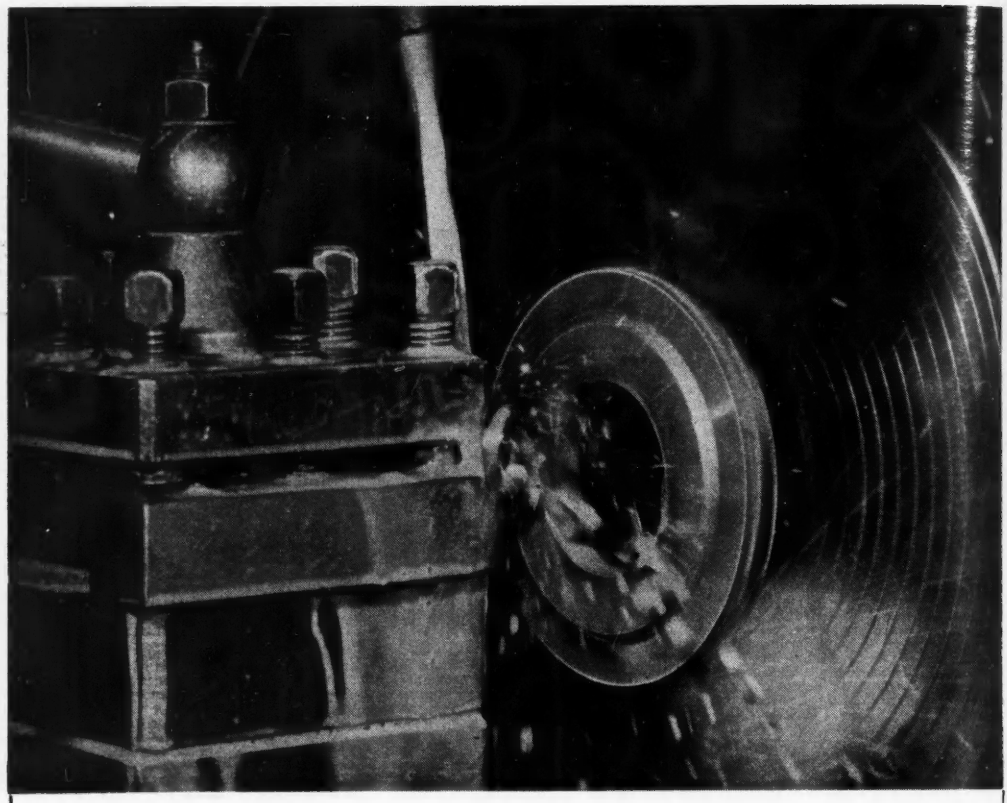

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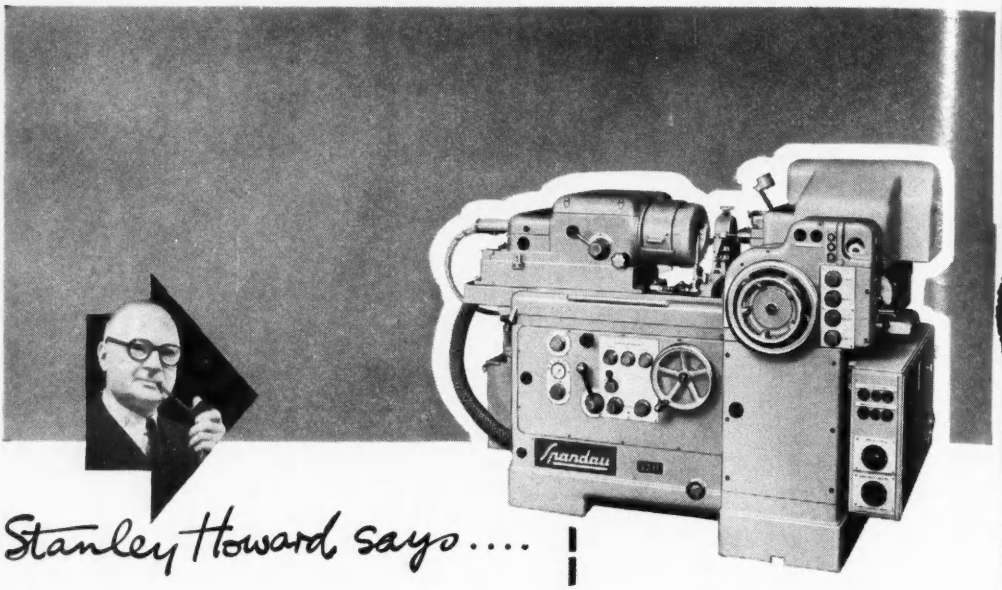

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THIS HIGH PRODUCTION
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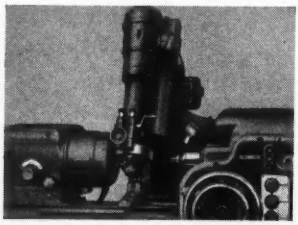
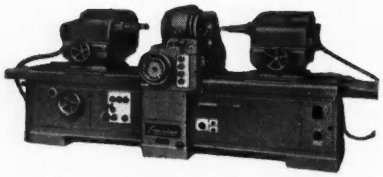


Illustrated here is the Facing Attachment with straight wheel for periphery grinding, which can be supplied as an optional extra.



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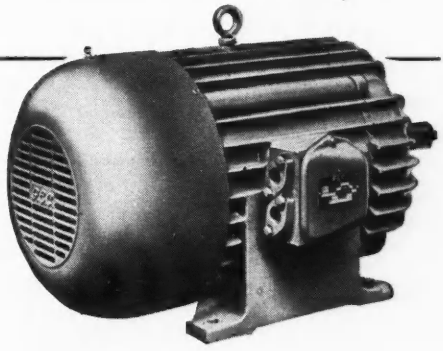

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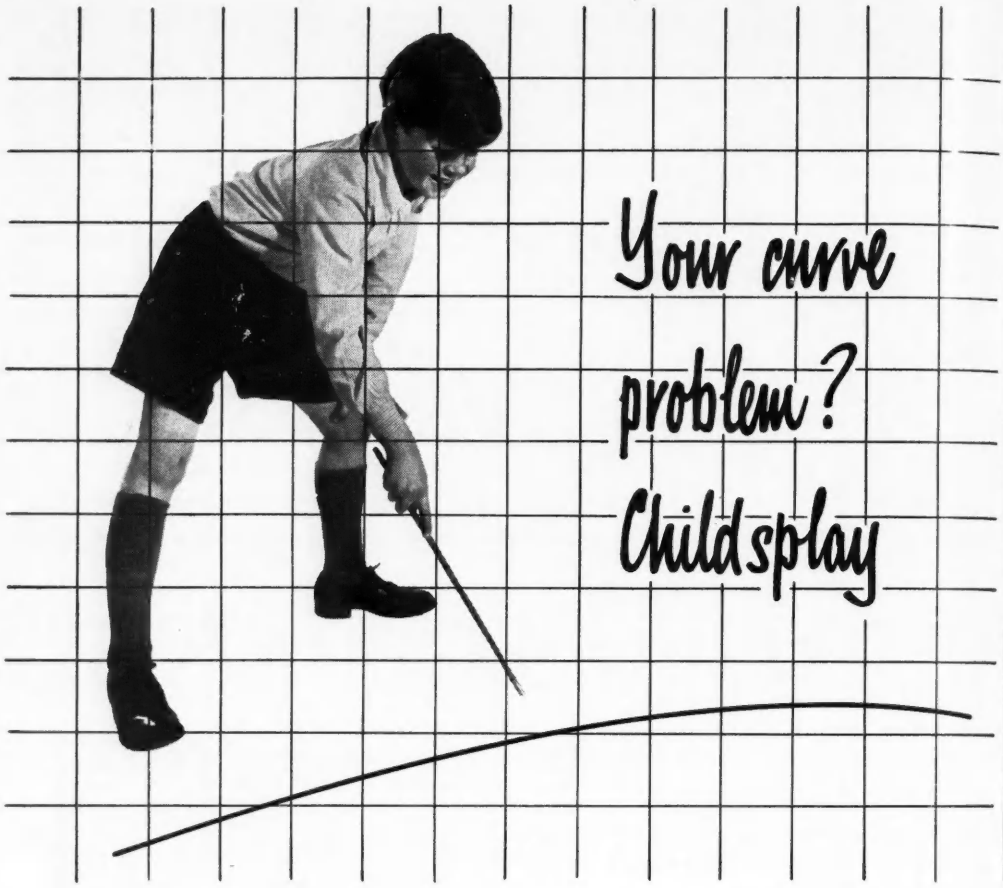

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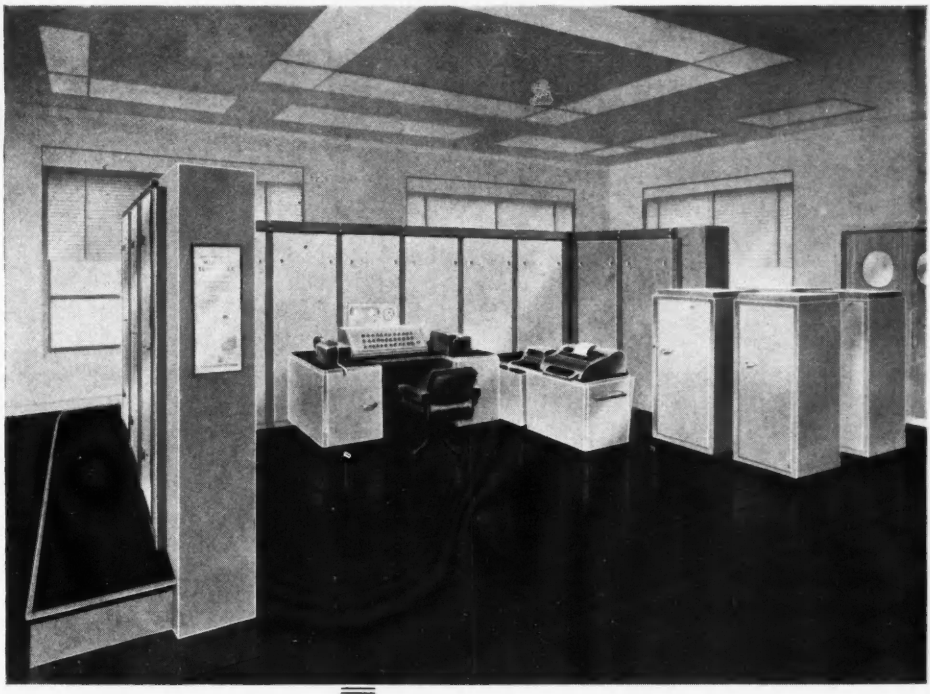

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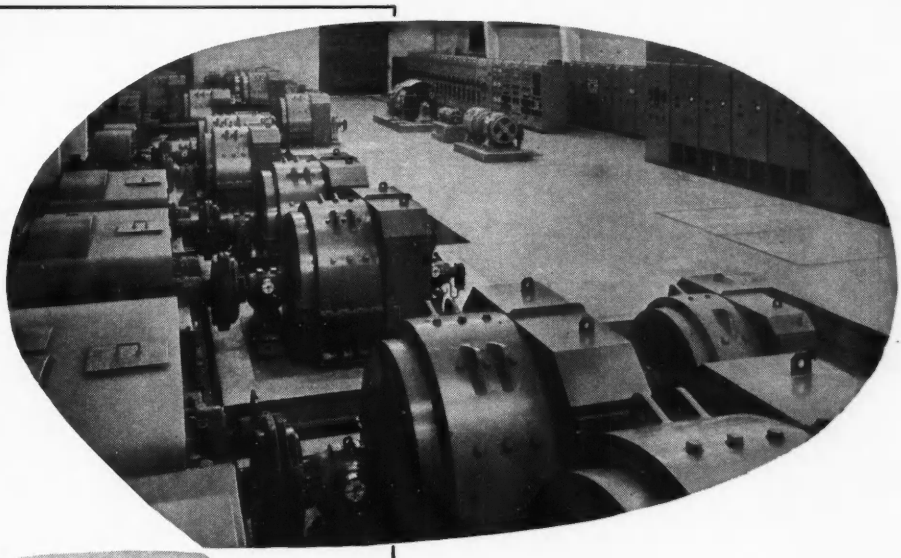

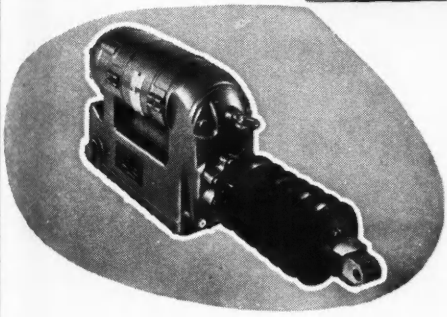

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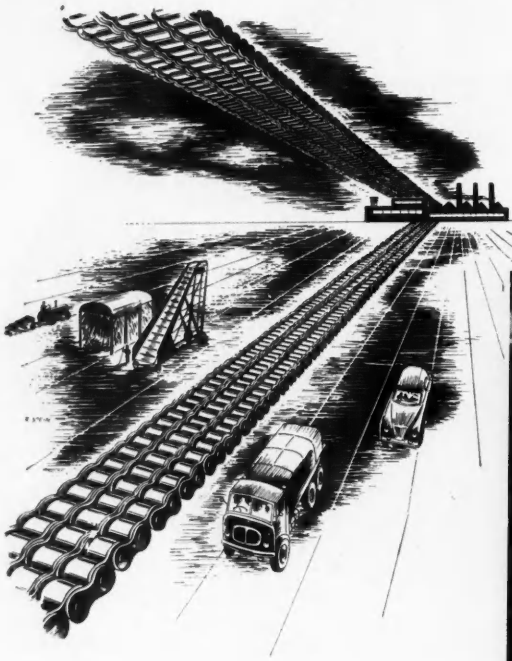
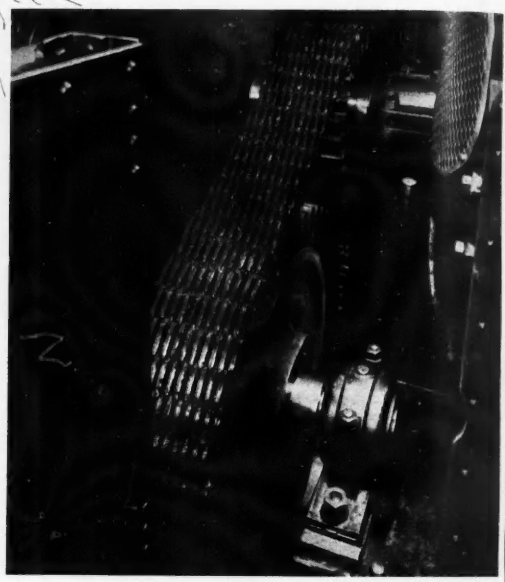


in the long run it pays to install MORSE chains



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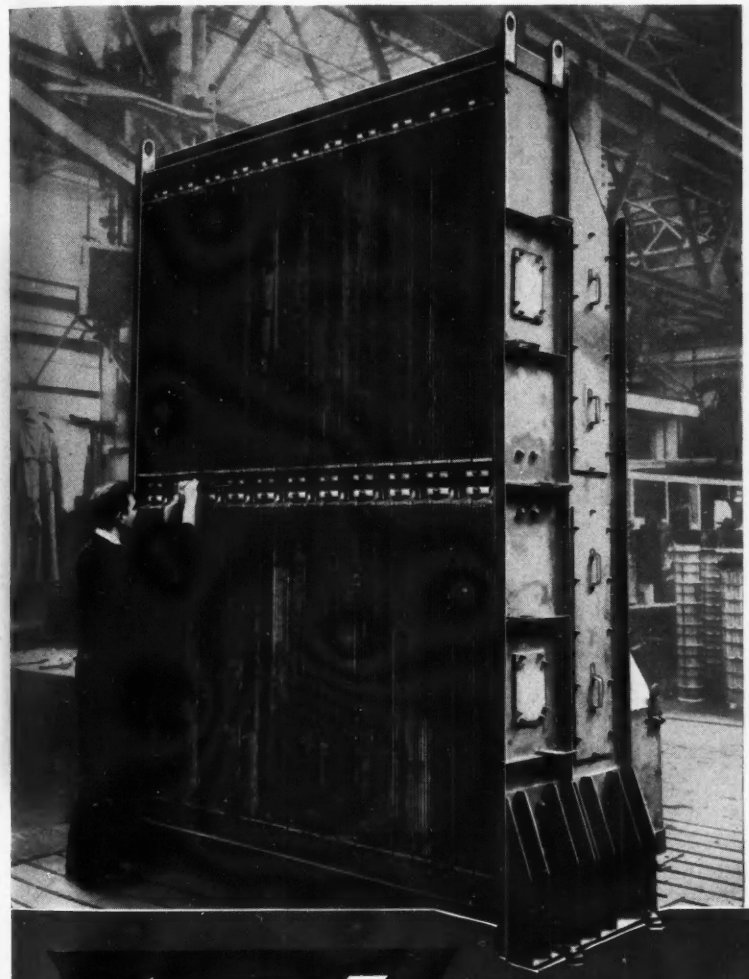

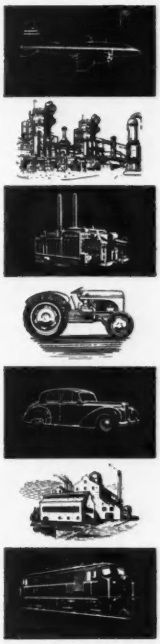

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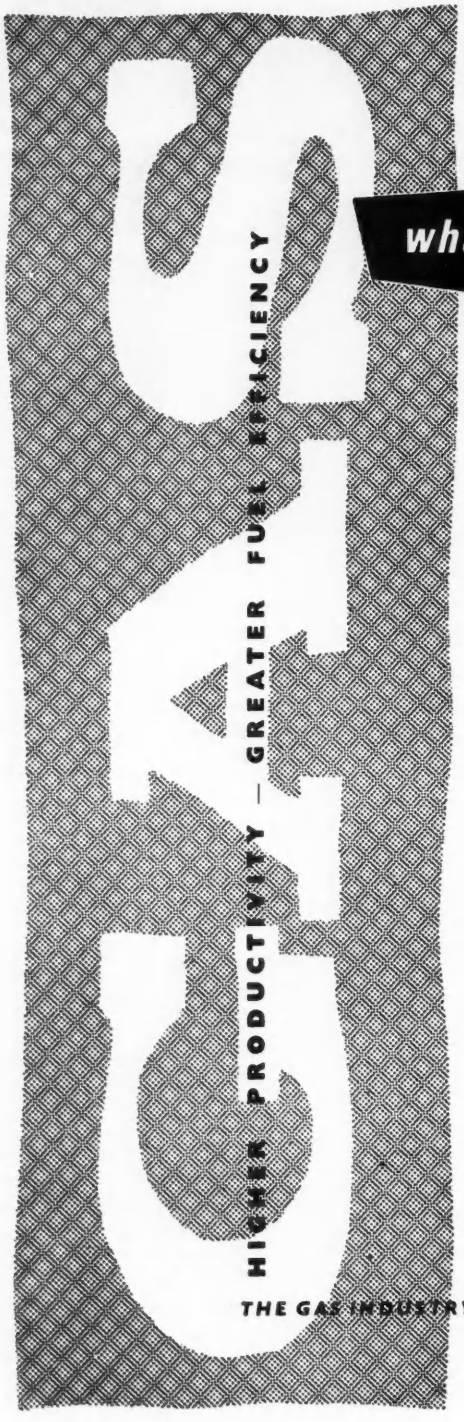

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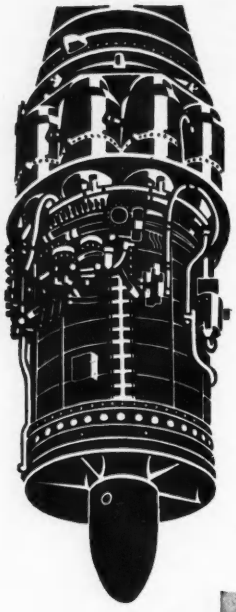

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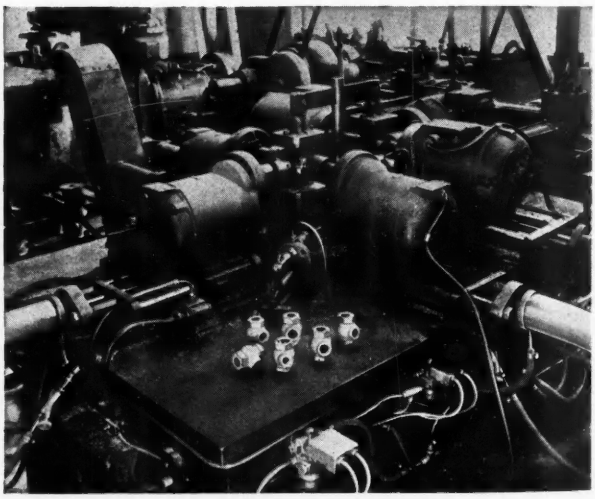

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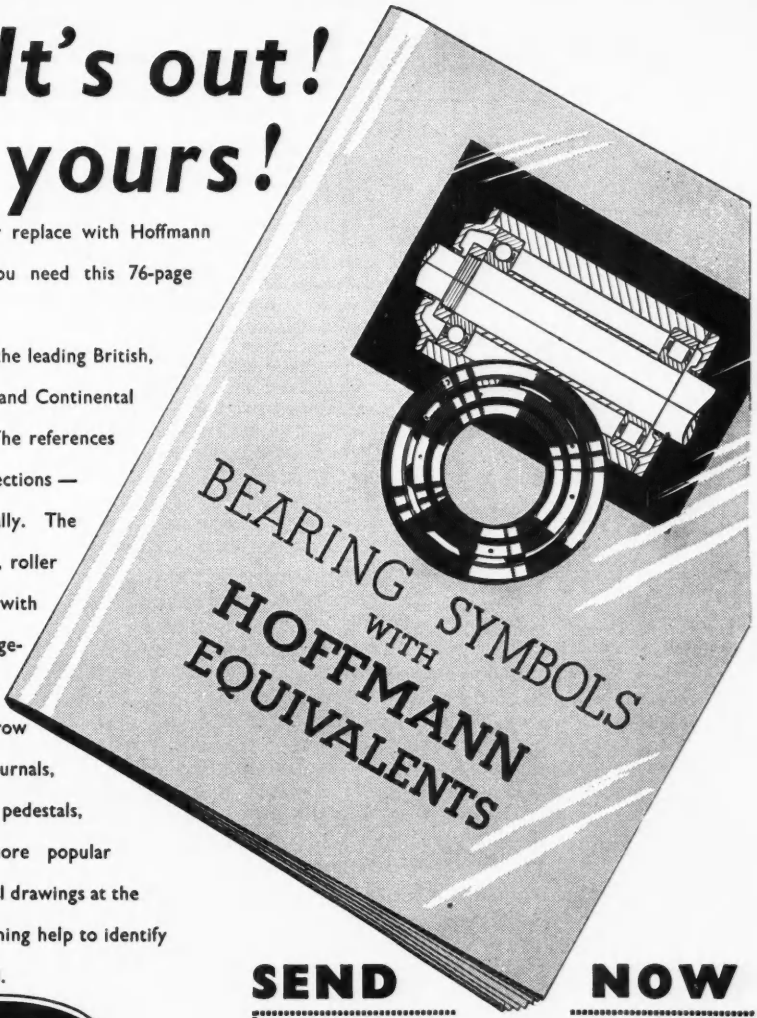

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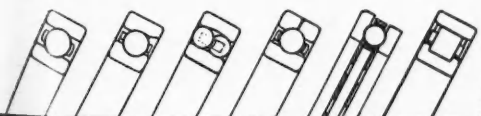

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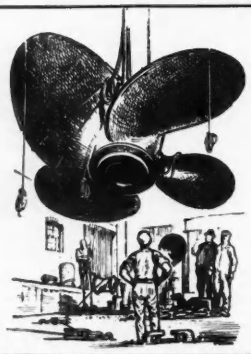

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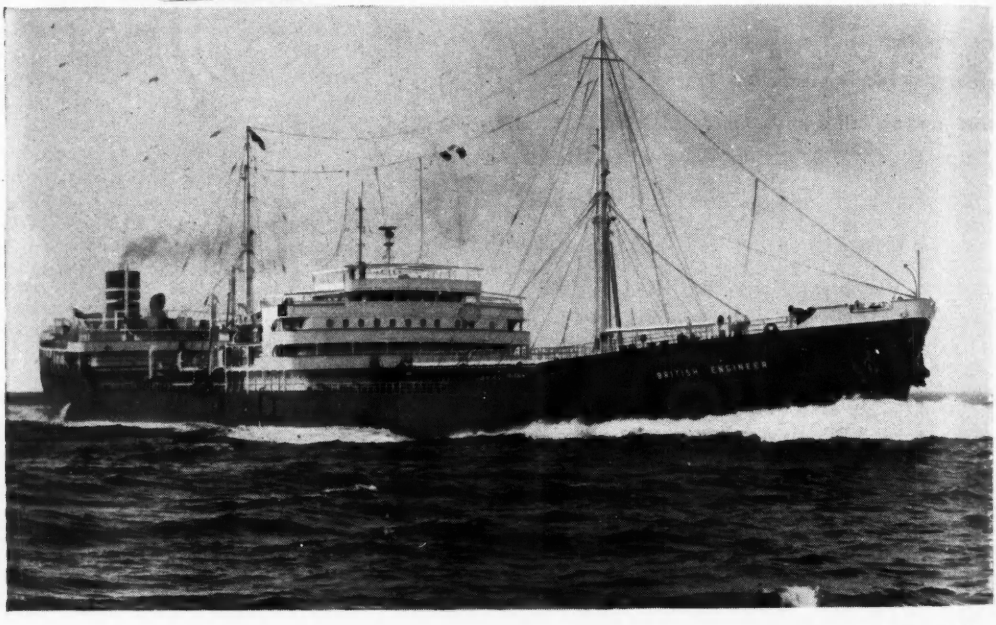
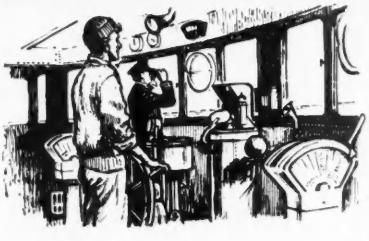


Not only in shipbuilding, but in most major industries, copper and its alloys play a vital part. The purpose of the Copper Development Association—a non-trading organisation—is to advise on the best uses of copper and its alloys. Its services are always available without charge or obligation.



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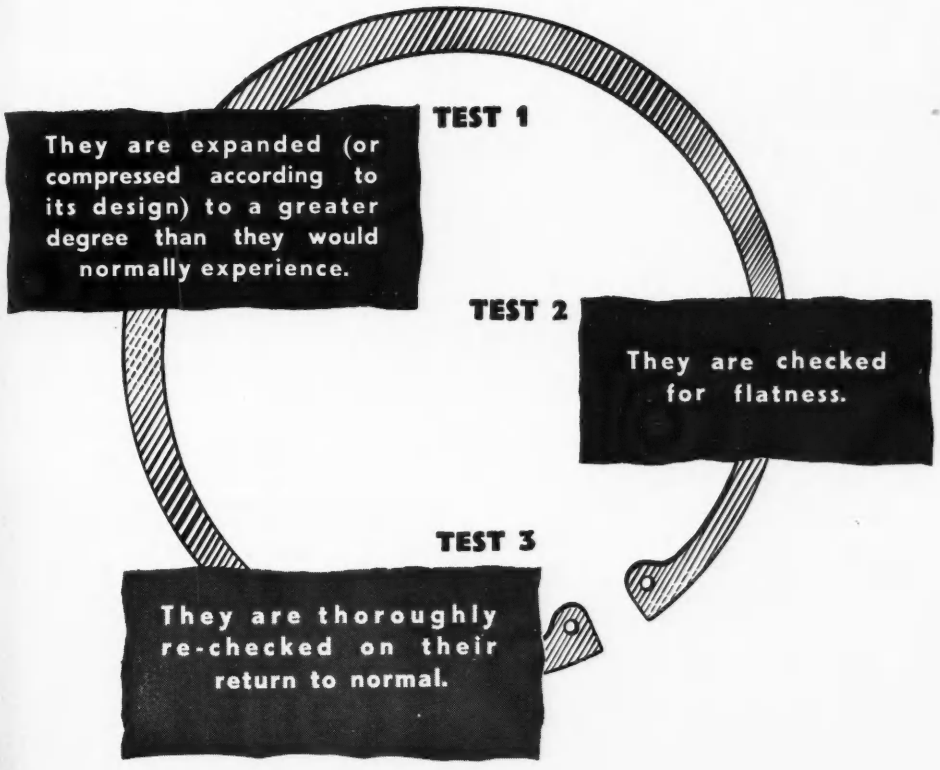
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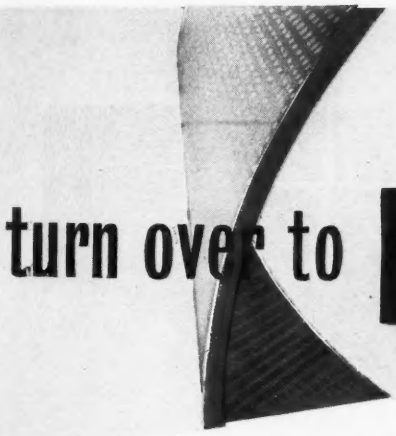

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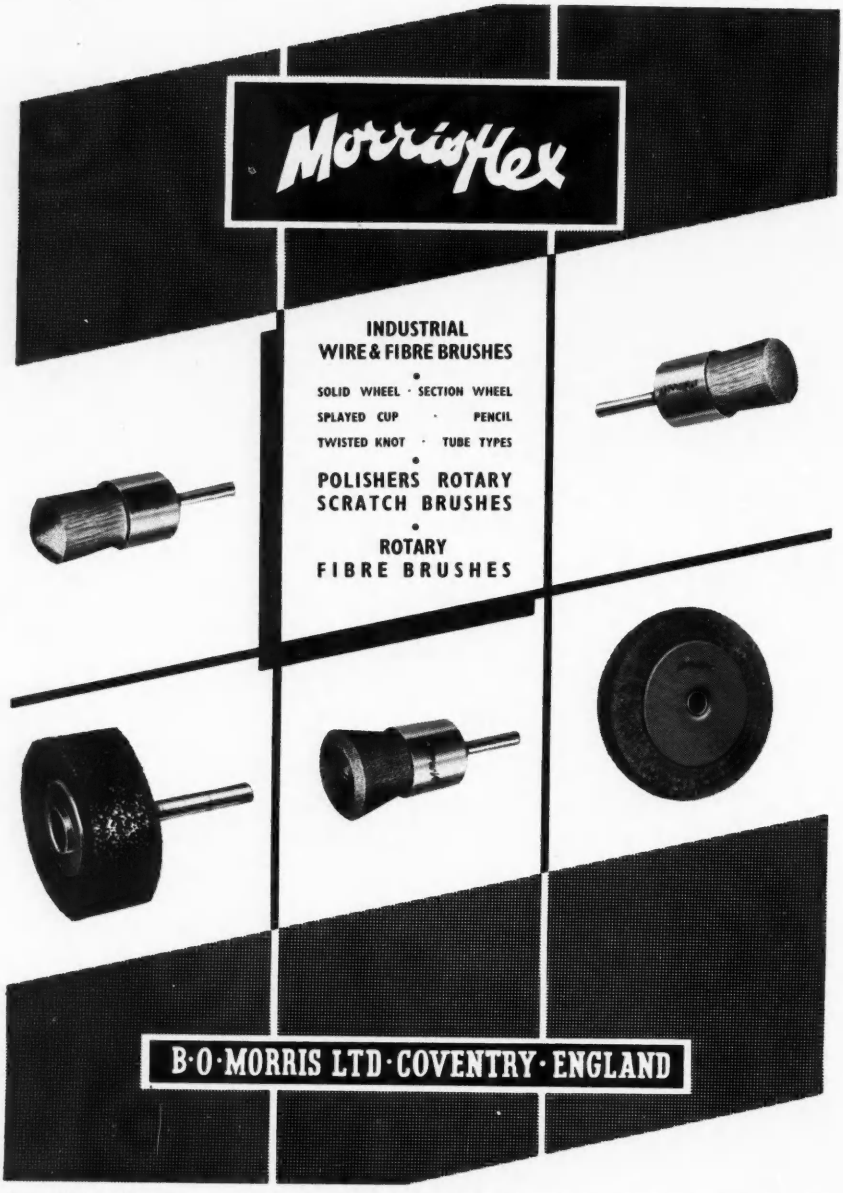

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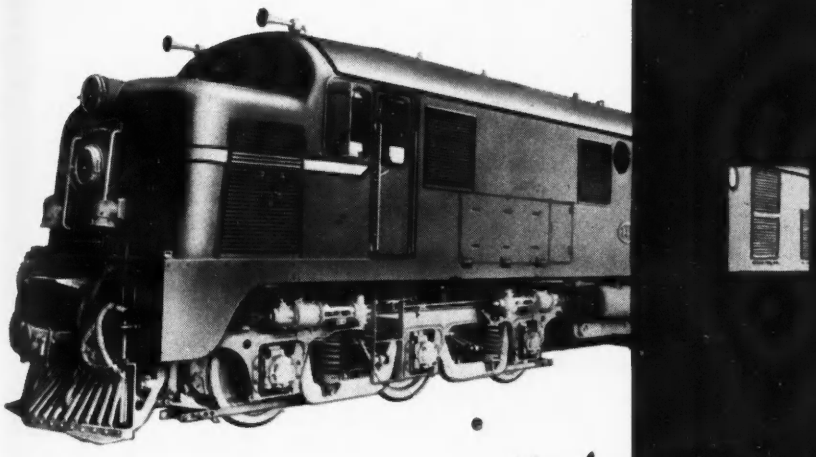

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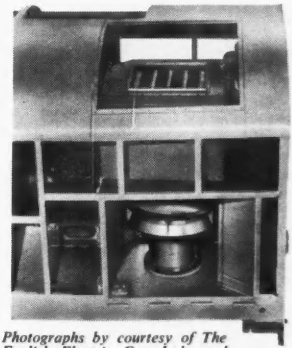

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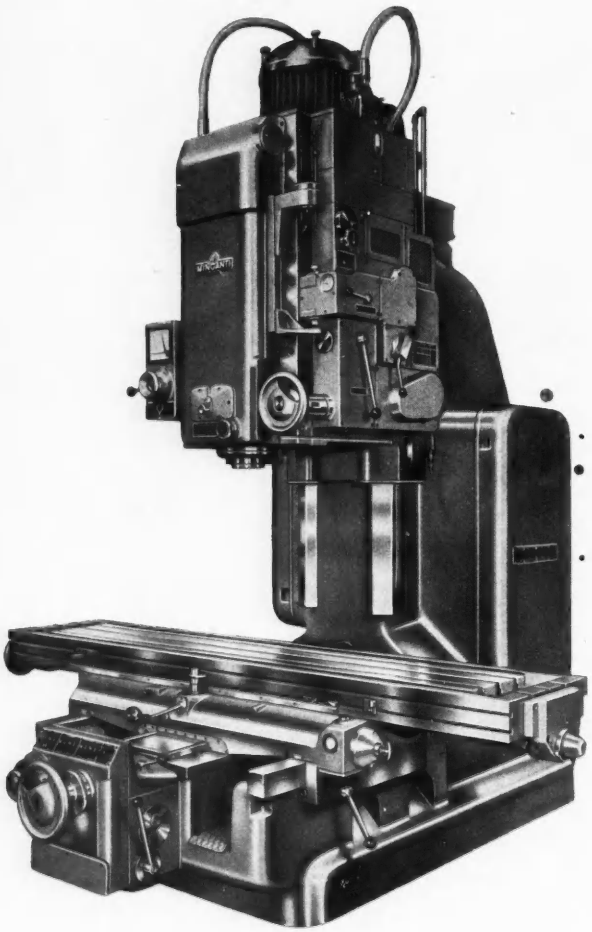

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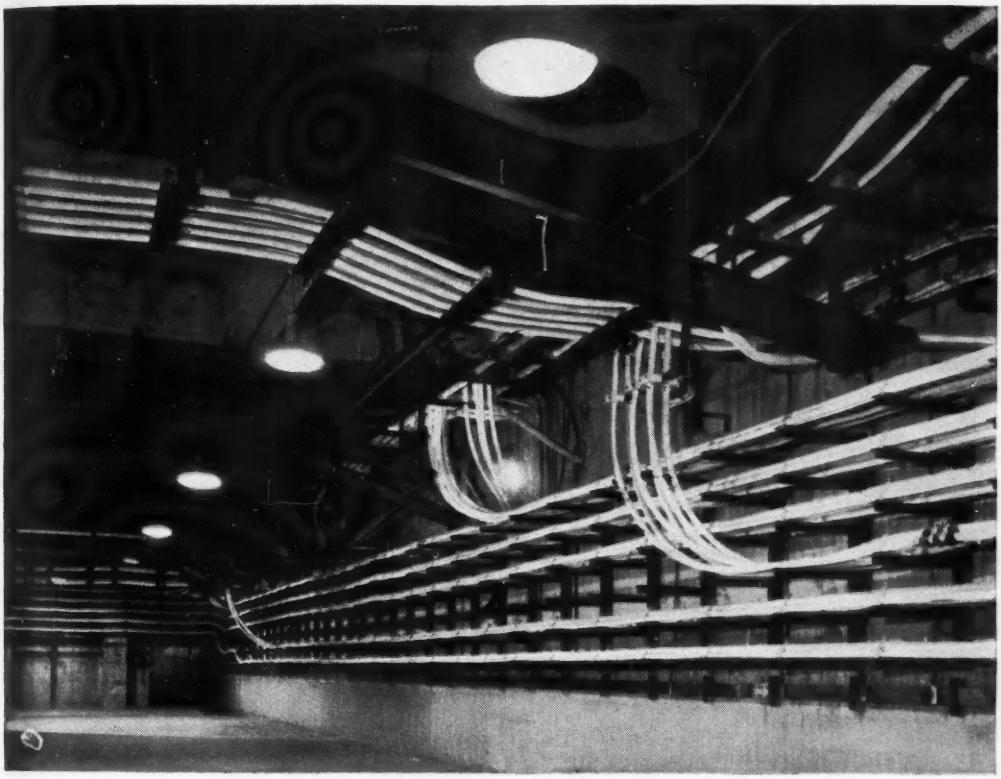

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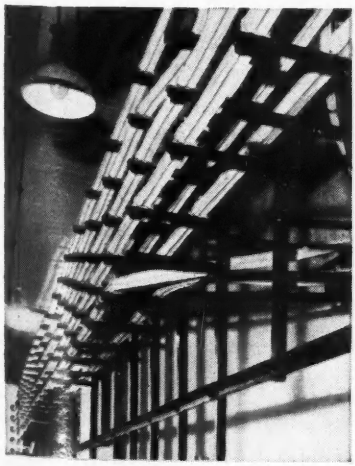

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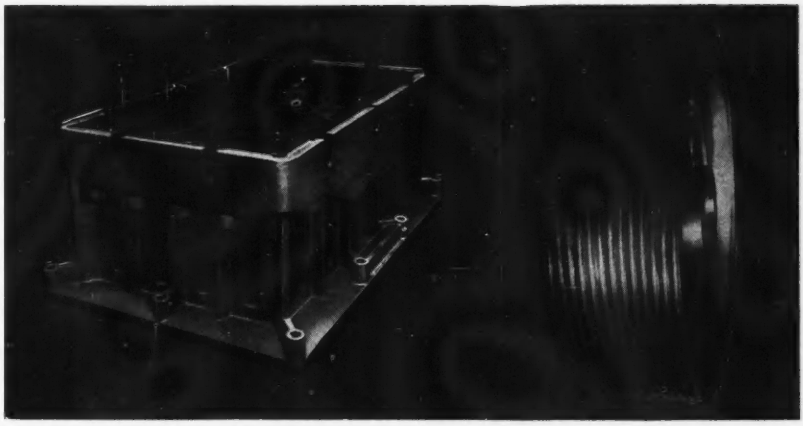

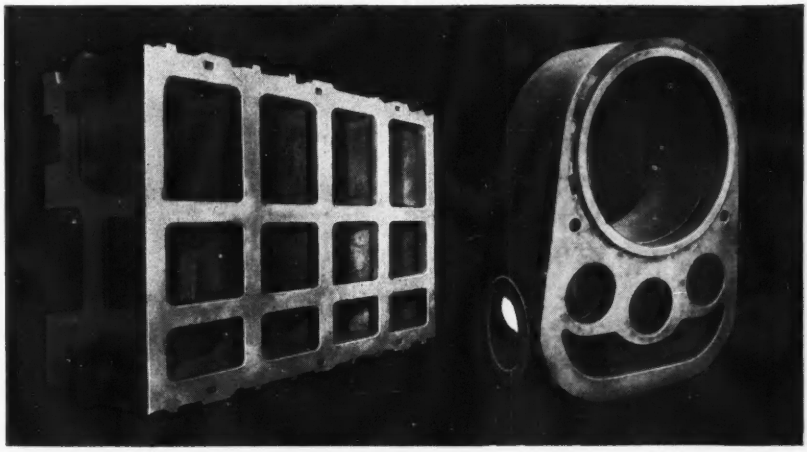

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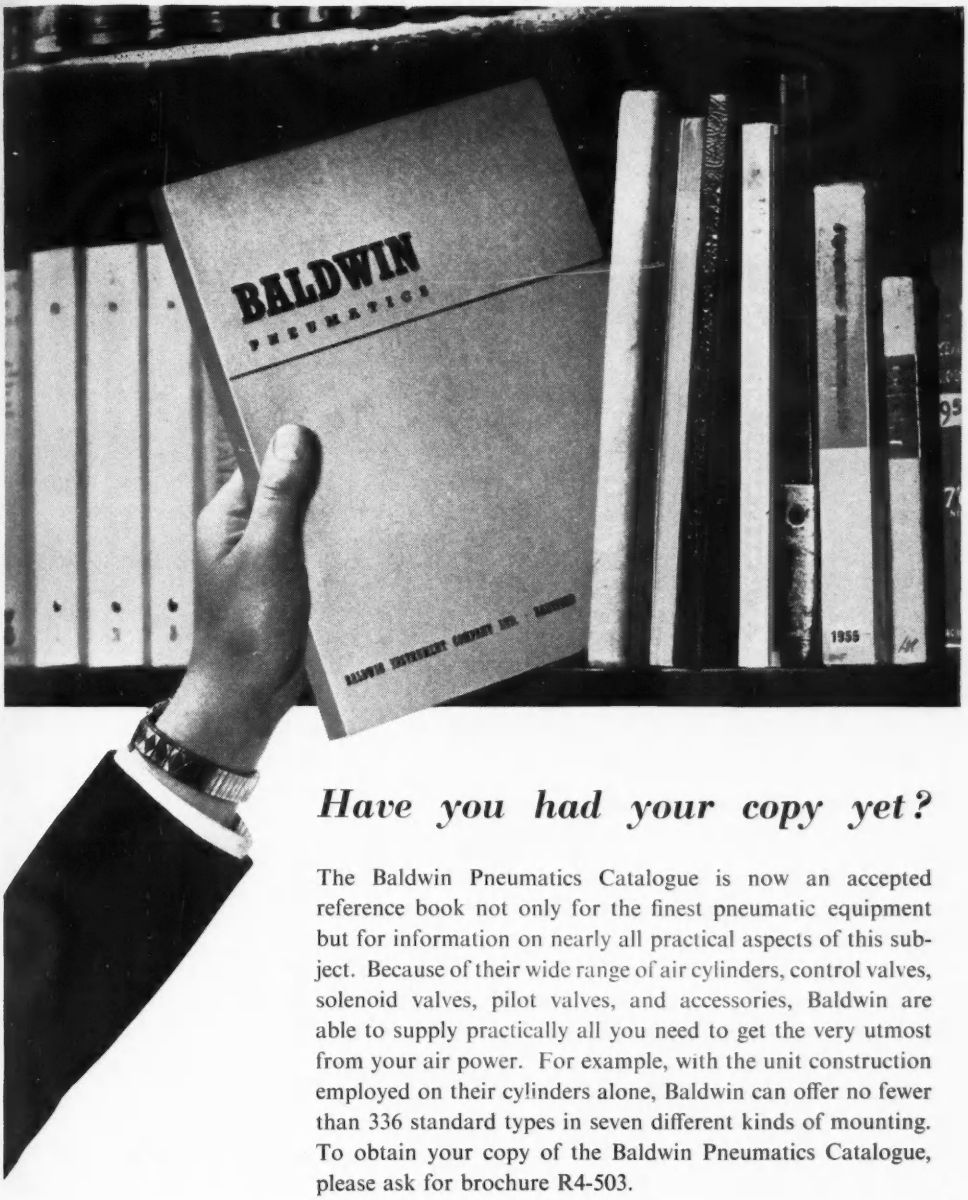

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The Baldwin Pneumatics Catalogue is now an accepted reference book not only for the finest pneumatic equipment but for information on nearly all practical aspects of this subject. Because of their wide range of air cylinders, control valves, solenoid valves, pilot valves, and accessories, Baldwin are able to supply practically all you need to get the very utmost from your air power. For example, with the unit construction employed on their cylinders alone, Baldwin can offer no fewer than 336 standard types in seven different kinds of mounting. To obtain your copy of the Baldwin Pneumatics Catalogue, please ask for brochure R4-503.

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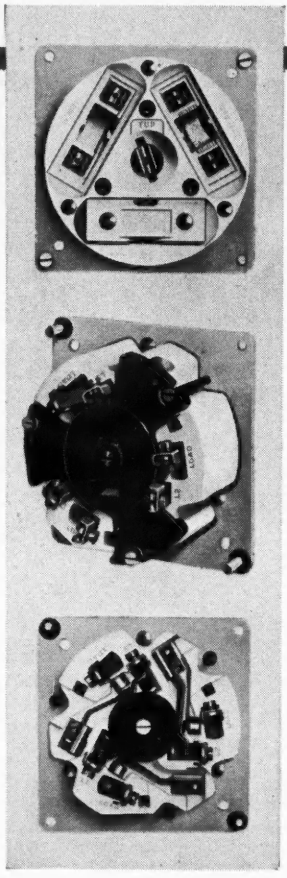
Attractively designed cover and cast iron case of the MEM Rotary Fused Isolator are finished in grey stove enamel.



Fuse inspection absolutely safe. Th fuse sockets are in lated by the renew of the cover and it impossible to tou live metal.

Wiring is especial easy. Heavy cla terminals are pr vided and are clea identified. An ind cator shows whethe the switch is on o off.

The three phase the robust c operated switch separated by th porcelain wall Contacts are s silver. Inspection simple once th plastic switch cov is removed.

Handsome appearance and high efficiency go hand in hand here, in the MEM Rotary Fused Isolator.

Designed for use with A.C. Motors on machine tools and other similar applications, this switch is of a slow break A.C. pattern rated at 15 amps., 500 volts. It will safely disconnect a stalled motor of 7½ h.p. taking six to eight times full load current.

The unit takes 15 amp., rewirable "Kantark Major" fuses or alternatively you can choose standard H.R.C. fuse links to the dimensions of B.S.88 1952, Appendix J.

Fuses can be inspected or renewed in perfect safety. The cover can only be removed when the switch is in the 'off' position, and then the fuse contacts are completely isolated from the incoming supply.

Two patterns are available, for flush or surface mounting.

MEM

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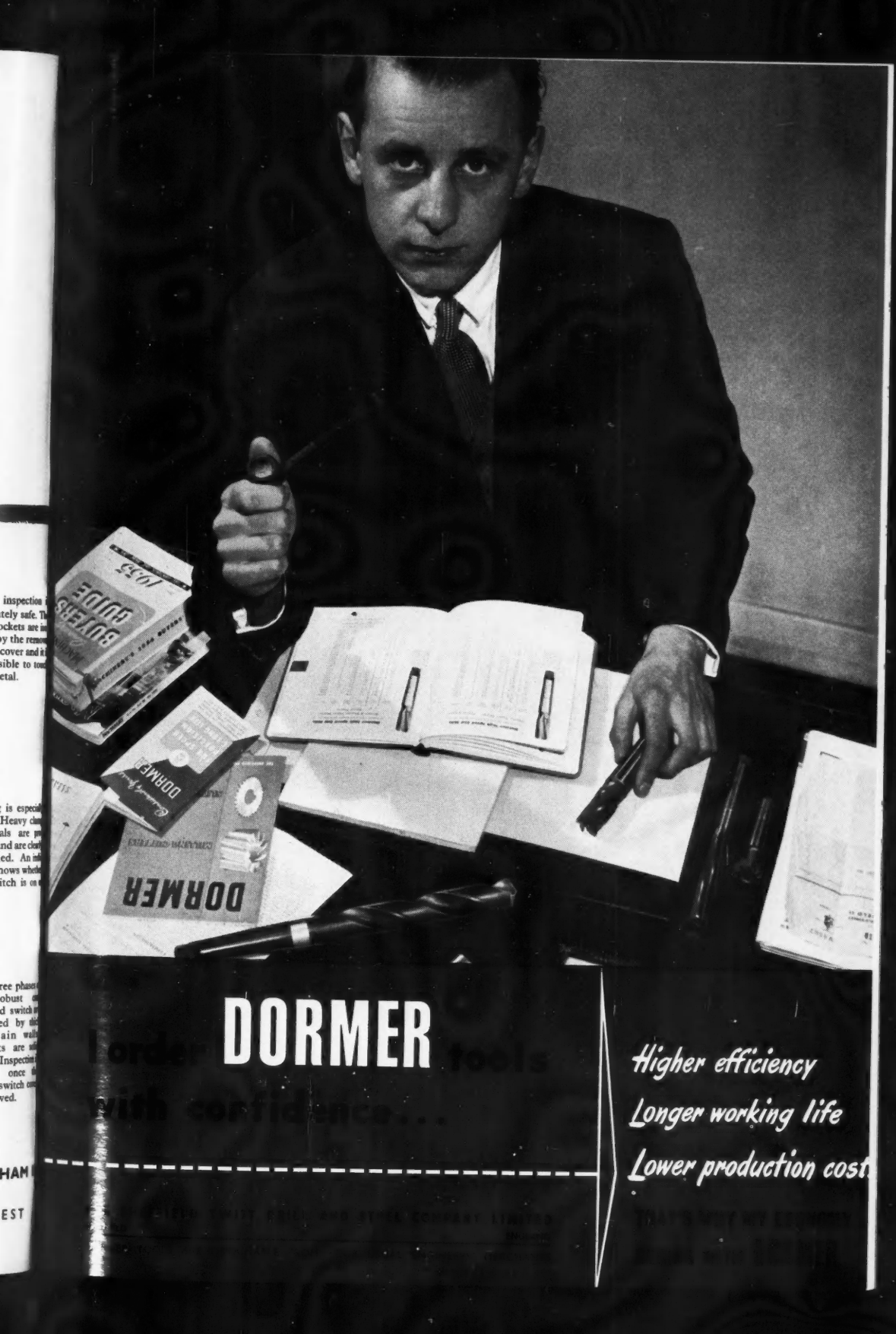

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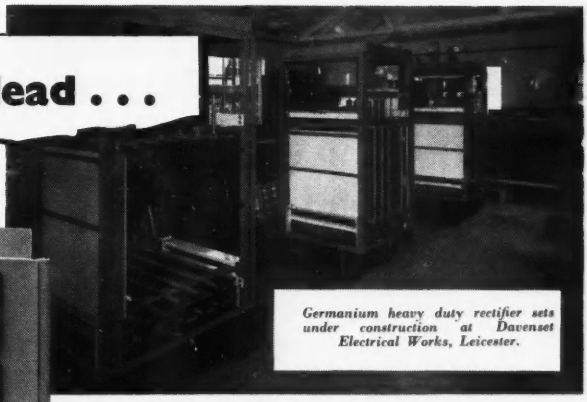

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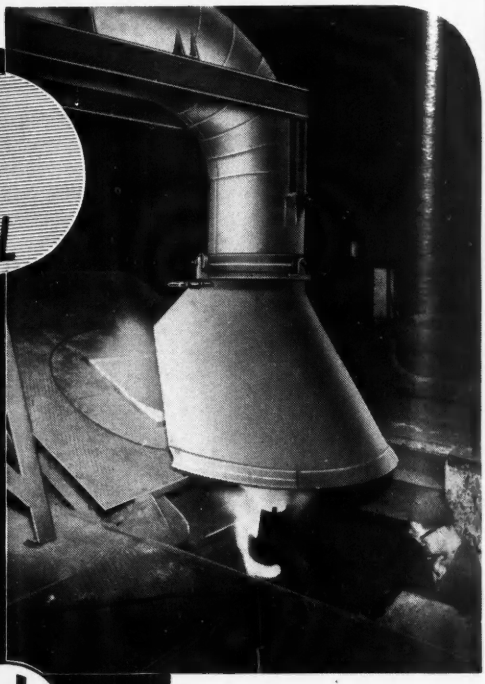

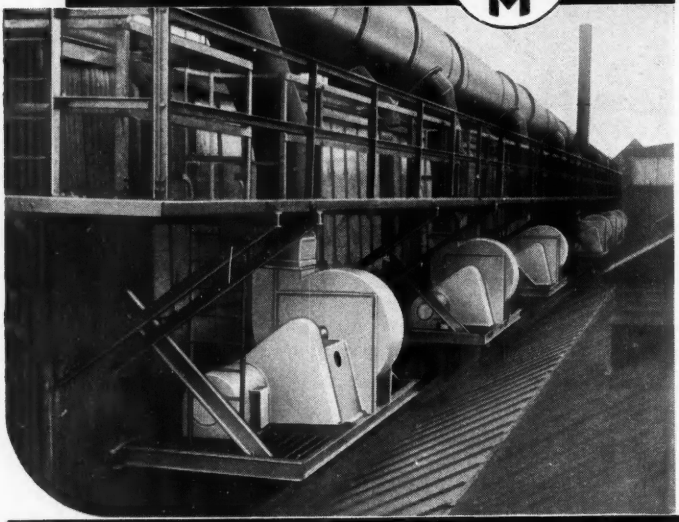

(Above) One of the specially designed HOODS dealing with the fumes from the furnace and mould when pouring.

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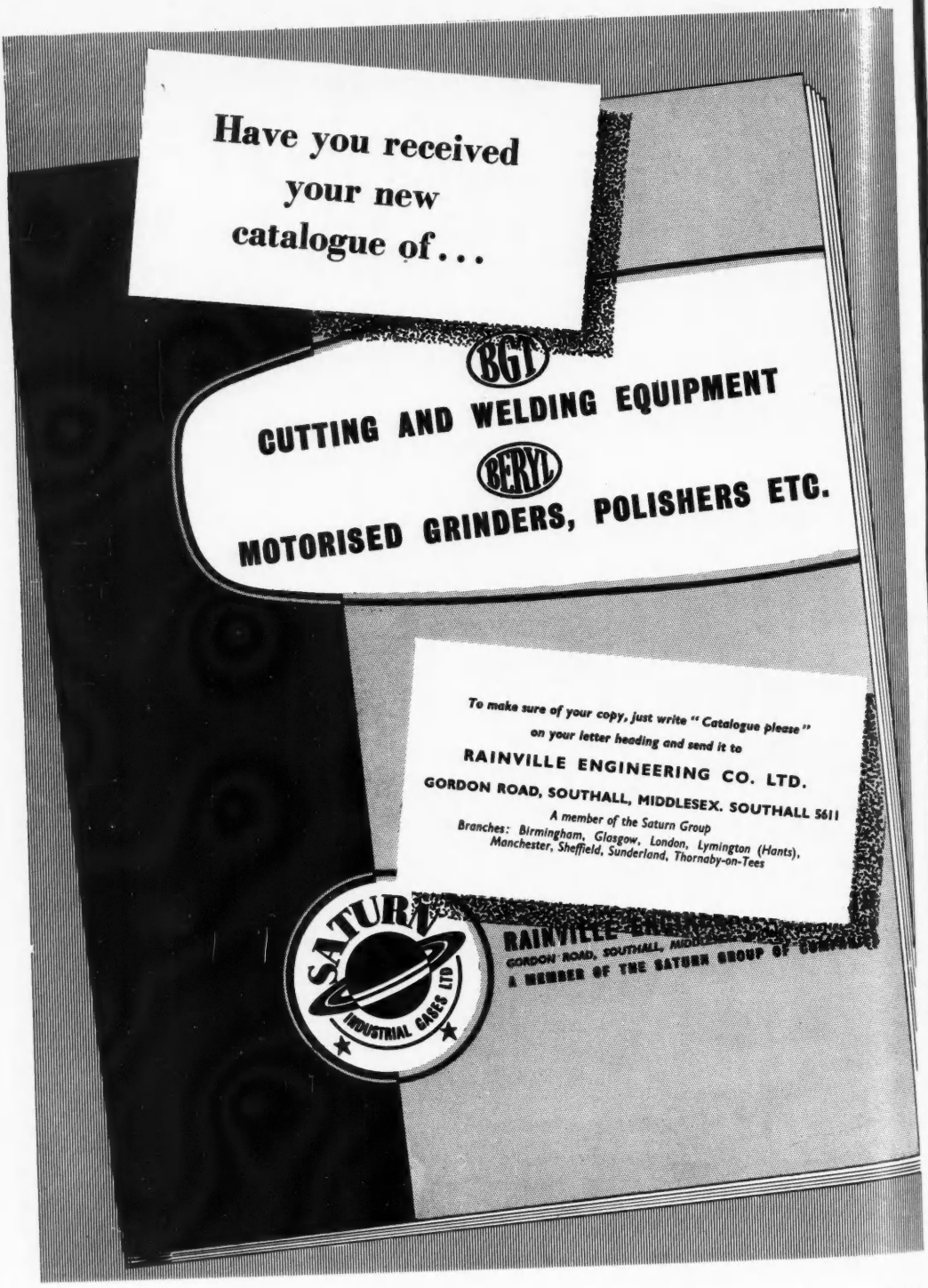
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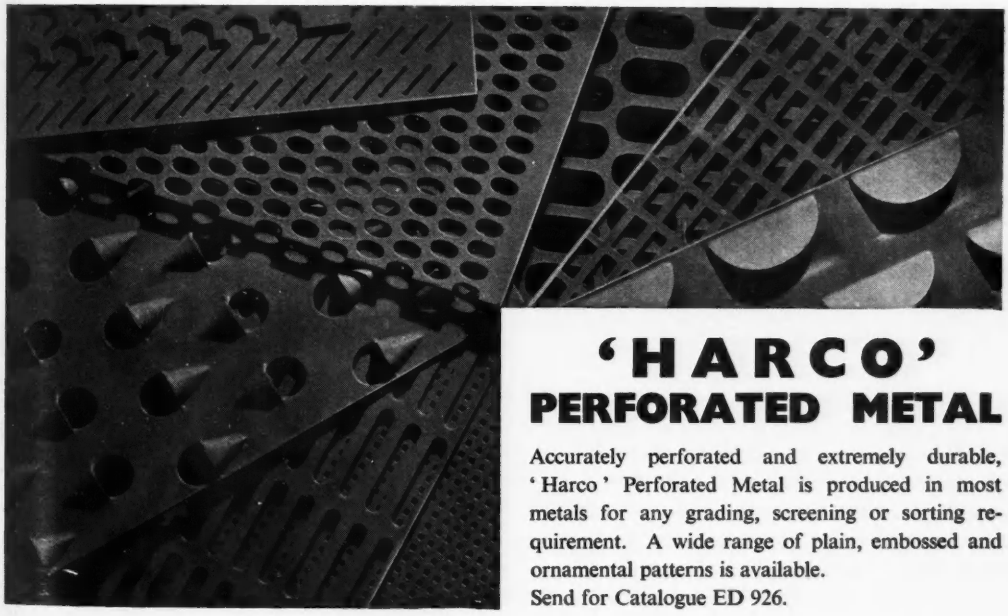

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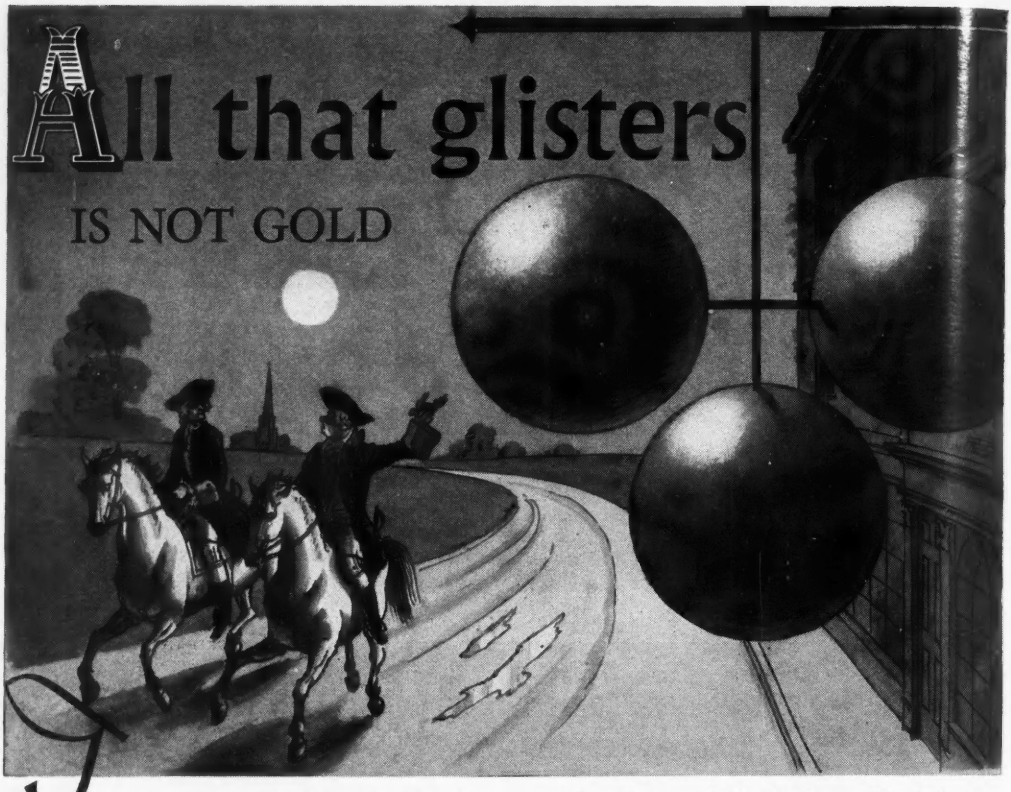


THREE GREAT golden balls glistened in the moonlight. "Zounds!" cried the First Robber — "there's as pretty a sight as ever I did see, all set out werry neat and orderly, and all a-ready for the taking of by two enterprising gents with an eye to business. Do you give me a leg, Skipper, and I'll part 'em from their moorings werry brisklike— afore ye can say Jack Ketch!"

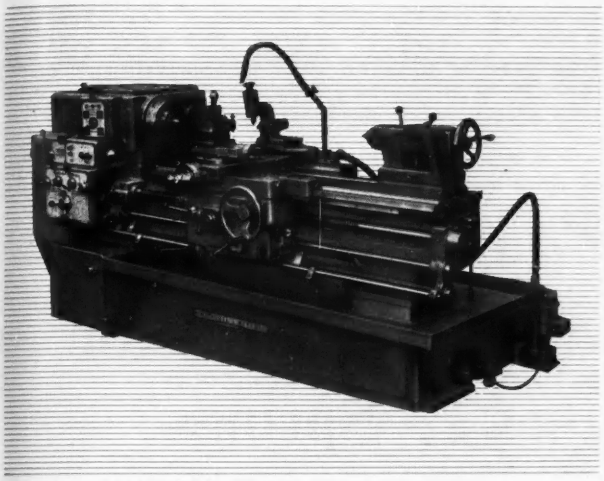
"Tch!" murmured his companion, a man of sharper intellect and wider experience than honest Jeremy —"such simple faith is sadly misplaced, old friend. These globes are neither gold nor other precious metal, being wrought — probably in Birmingham — of brass. Hollow at that —" he added testily, rapping one of them with his cane. It gave out a dull, lack-lustre note.

Jeremy frowned. "Werry misleading and unethical," he muttered, "It's them sort of things from what man's ingratitood springs." He paused, pleasingly fuddled by his little rhyme.

"Speaking of springs," said the Captain darkly, and sounding suspiciously like an advertisement, "there's *another* bone of contention in this imperfect world. Did you know that the cheapest of springs may look every bit as good as the finest quality spring, specially designed and made for ultra-high performance? And, like the three golden balls, it's only when you come to try 'em out that you find you've been conducted up the garden path. Truly 'All that glisters is not gold'! Which reminds me, I really must redeem Lord Hartlebury's timepiece..."

Advertiser's Announcement

M-W. 421



Woodhouse and Mitchell 8½" centre lathe

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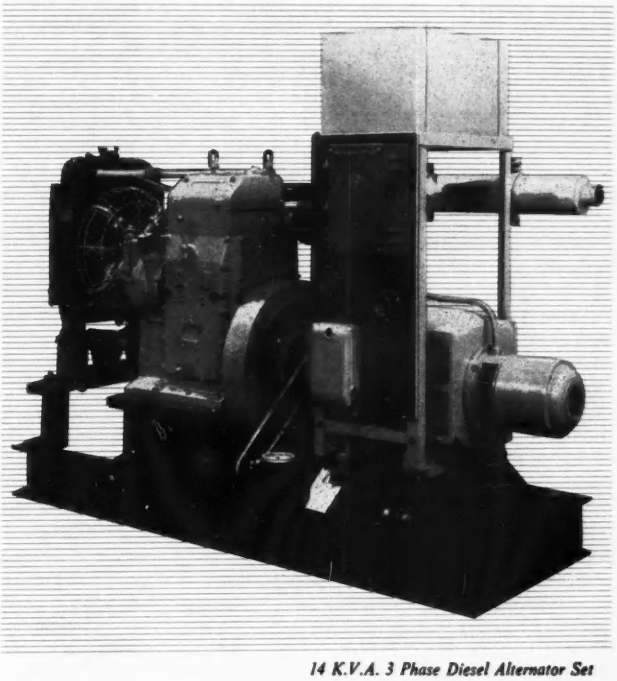

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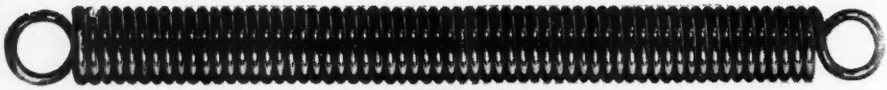

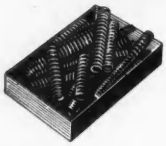

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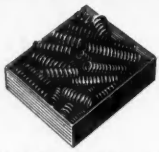

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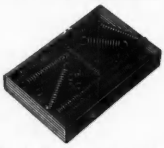

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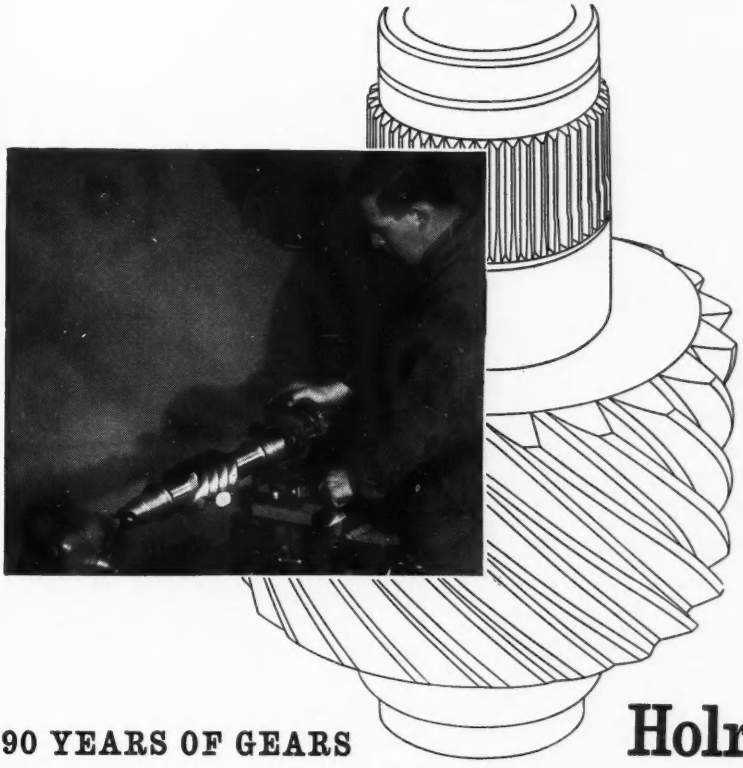

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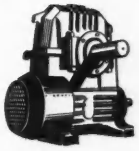

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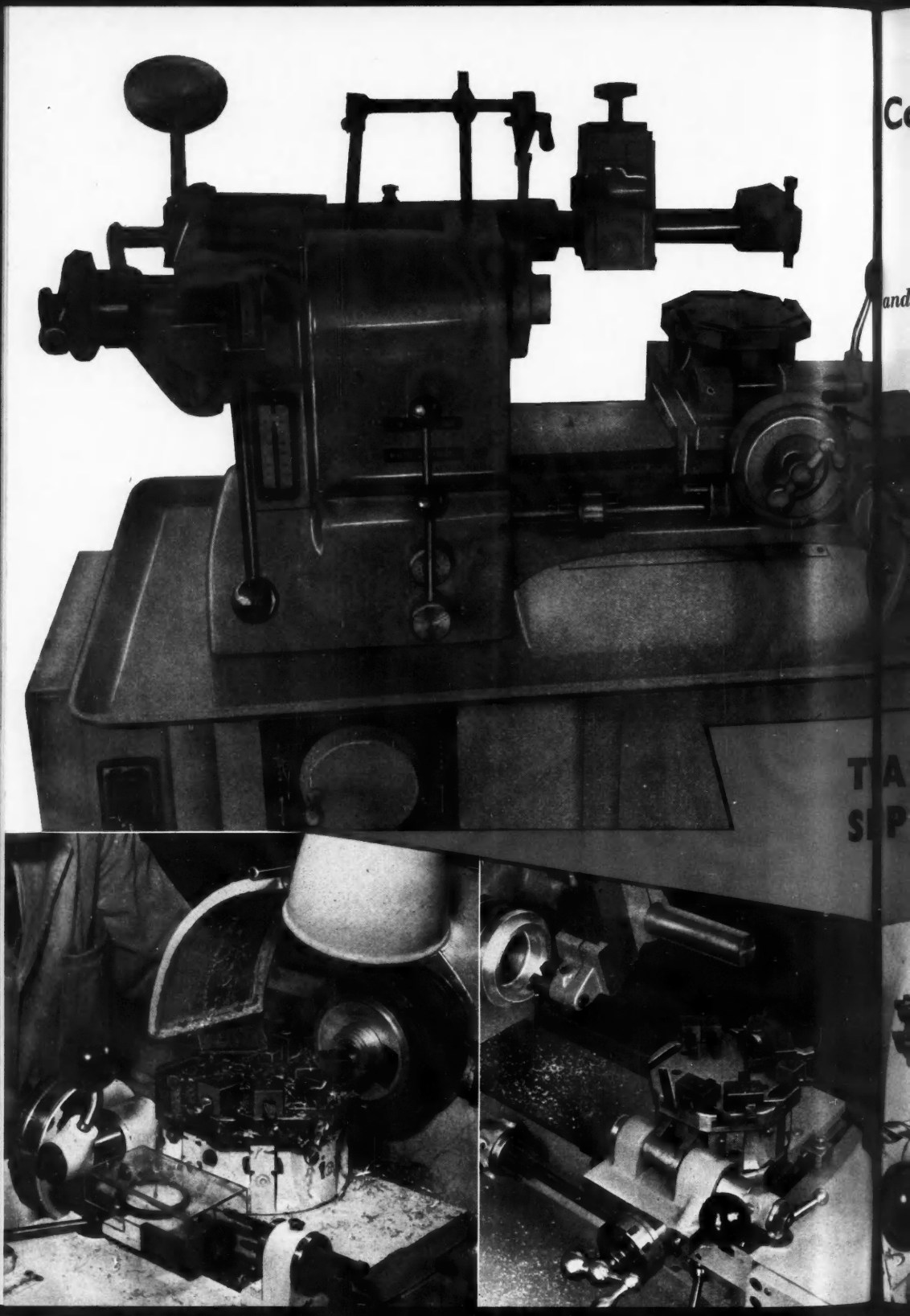

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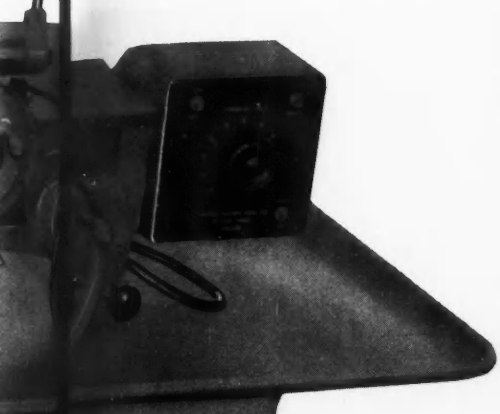

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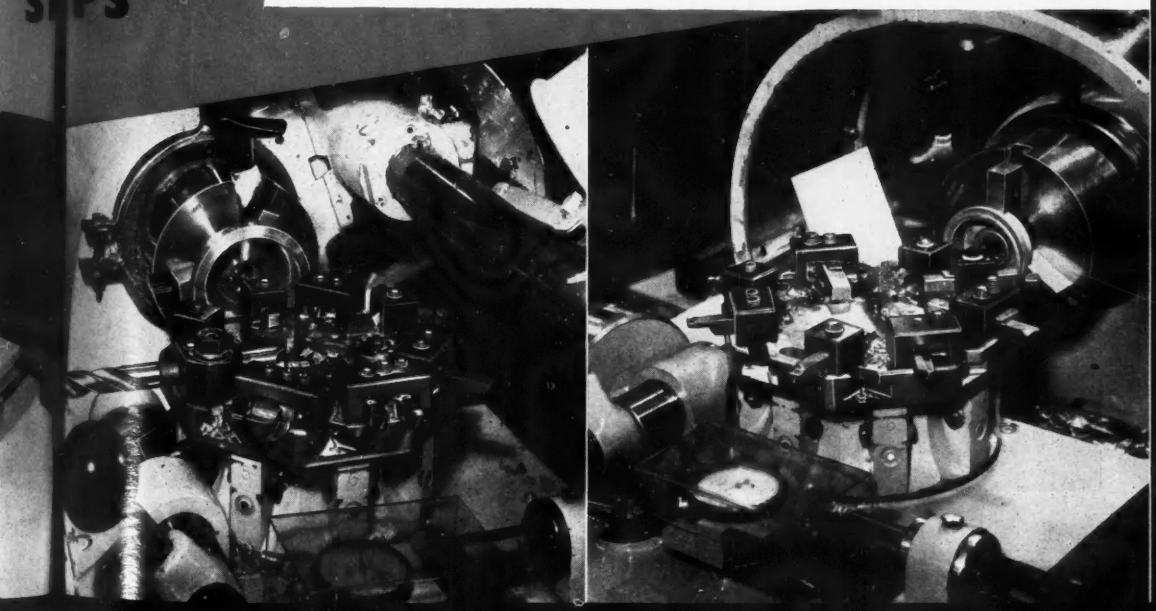

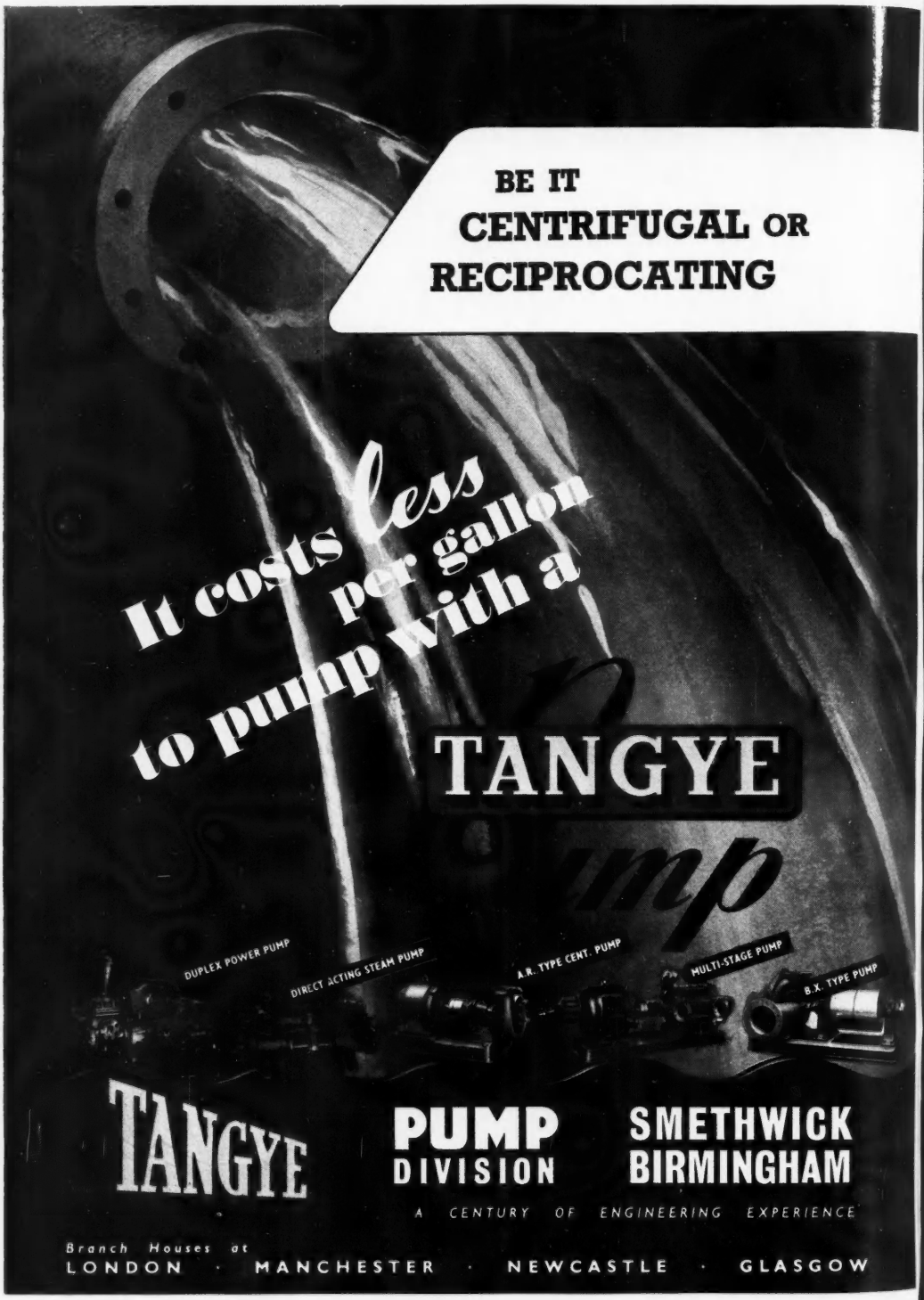
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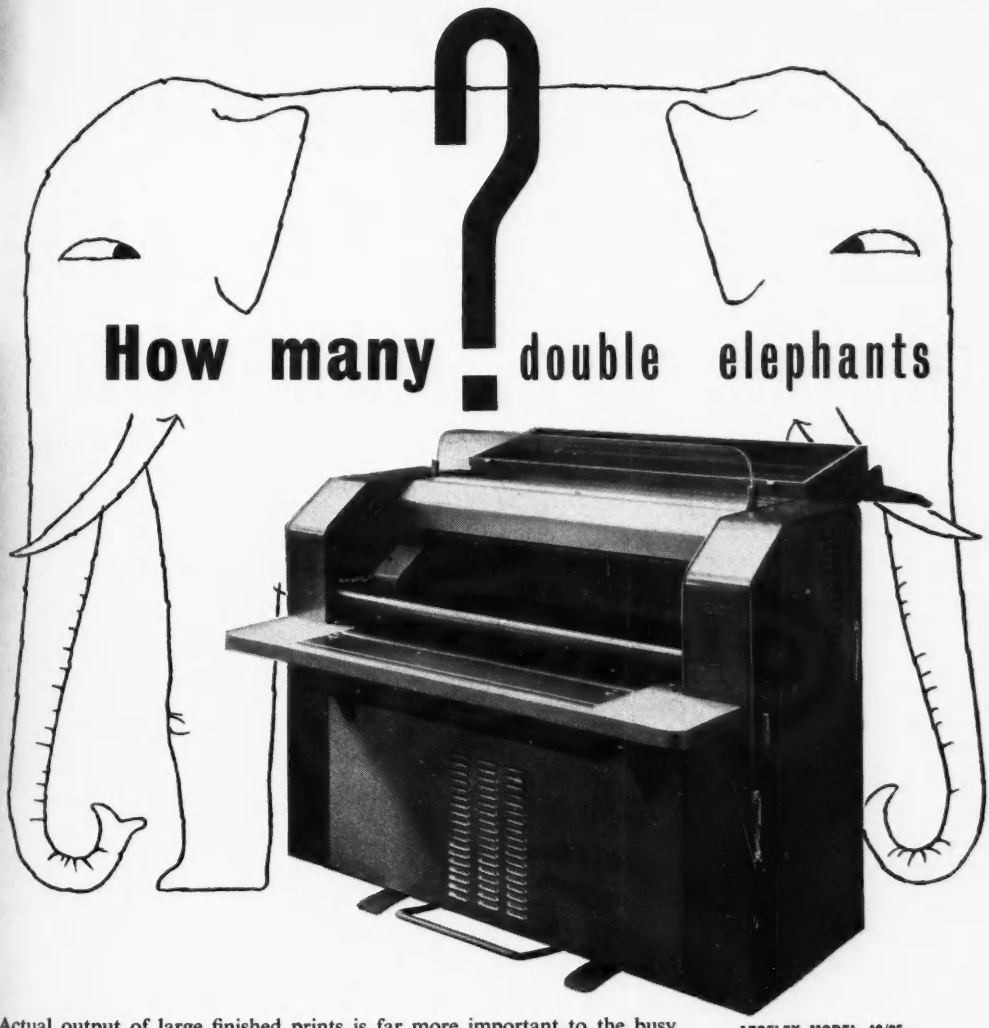

Actual output of large finished prints is far more important to the busy print room than theoretical claims about maximum operating speeds. Viewed from this angle, the performance of the AZOFLEX Model 46/35 Combine Printing and Developing Machine is altogether outstanding, for it is capable of turning out prints at a rate well in excess of 1,000 Double Elephants a day, year in and year out. Exposure, development and print delivery are all synchronised for an even flow of finished work and optimum quality is always ensured because Azoflex is the only photo-printing process to apply the correct quantity of developer, irrespective of running speed. In addition, the process is free from unpleasant fumes and requires no complicated ventilating system.

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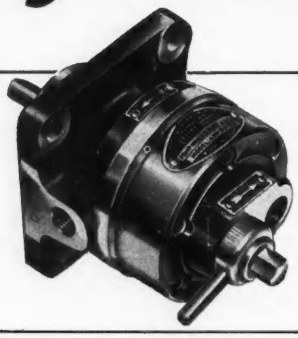
Hydraulic Pumps



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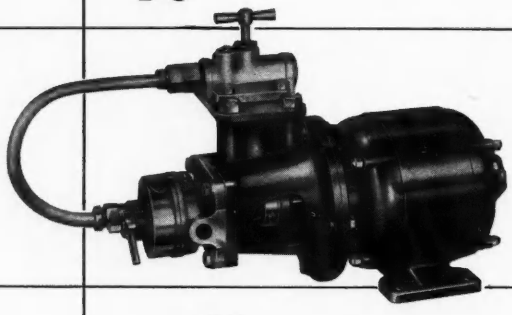

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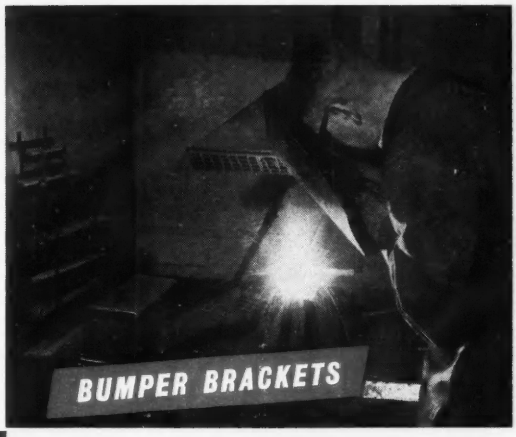
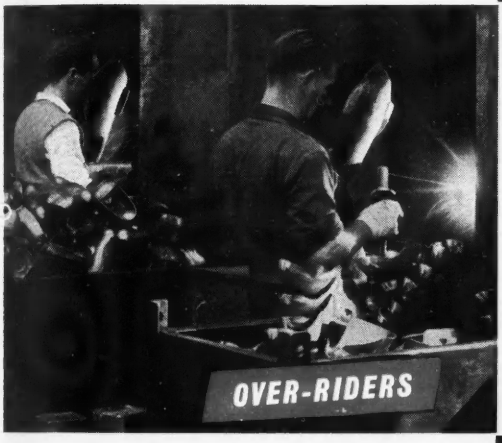


● *Multiweld O.V. Electrodes being used for arc-welding Bumper Brackets.*



● *In the production arc-welding booths, operators are using Multiweld O.V. Electrodes to weld brackets into 'deep drawing' steel over-rider shells.*

MULTIWELD O.V. is a mild steel electrode with a heavy extruded coating designed especially for use with AC but working equally well on DC. Multiweld O.V. is for use in all positions and is excellent as a touchweld electrode for vertically upward fillets. They are made in 6 sizes, the larger sizes are used downhand on heavy work. Multiweld O.V. conforms to B.S.S. 639 Class A, Lloyds Register of Shipping, Ministry of Transport and Civil Aviation.

Multiweld O.V. outstanding characteristics are:

Very stable arc—Ease of striking arc—Excellent finish of the bead—Very low spatter loss—Exceptionally easy slag removal—High quality weld metal—Exceptionally high deposition rate—Multiweld O.V. is generally easier to use than any similar electrode.

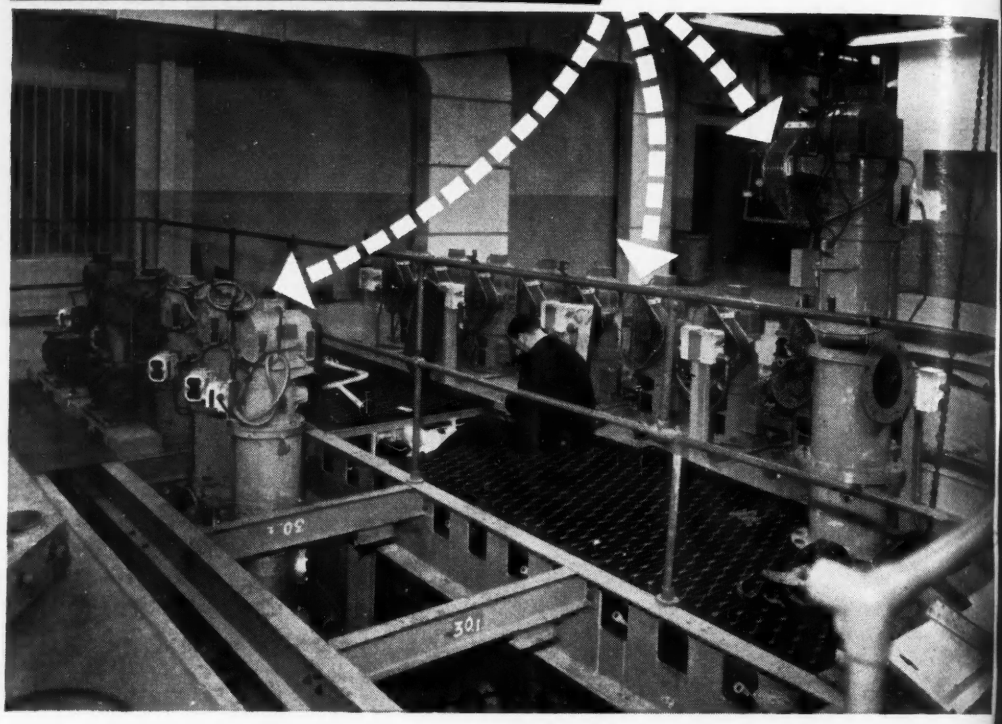
Multiweld O.V. is packed in the following sizes: $\frac{3}{32}$, $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{1}{4}$ and $\frac{5}{16}$. Like all Lincoln Electrodes Multiweld O.V. comes to you in sealed moisture-proof and airtight metal containers which keeps them absolutely dry.

● *Multiweld O.V. Electrodes and a Lincoln arc-welding Generator being used for welding 18/8 stainless steel steering wheel spokes to the steel rims.*

Largest manufacturers of D.C. Welders in the United Kingdom

LINCOLN ELECTRIC CO LTD · WELWYN GARDEN CITY · HERTS · WELWYN GARDEN 920 EIS

HELIOCENTRIC GEARS IN ACTION No. 6



PLANT FOR TERYLENE

The photograph shows Heliocentric Reducers being installed at Wilton Works on melters for spinning machines used in the manufacture of TERYLENE. In addition to this battery of twenty, Heliocentric Reducers have been supplied for other sections of the Plant and for TERYLENE Plants in Canada and on the Continent.

Photograph by courtesy of Imperial Chemical Industries Limited.

Engineers not already familiar with the advantages of the Heliocentric Reducer are invited to write for a copy of a comprehensive, fully illustrated brochure.

HELIOCENTRIC

A SABEN PRODUCT

SANDERSON BROS. AND NEWBOULD LTD., ATTERCLIFFE STEELWORKS, P.O. BOX 6, NEWHALL RD., SHEFFIELD 9

halves the weight... lengthens life... reduces cost

305

Regd. Trade Mark

This very famous continental
White Bronze Bearing Alloy (Brit. Pat. 725818)
is now made in Great Britain.

We would like to send you all details.
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Member of the Owen Organisation.

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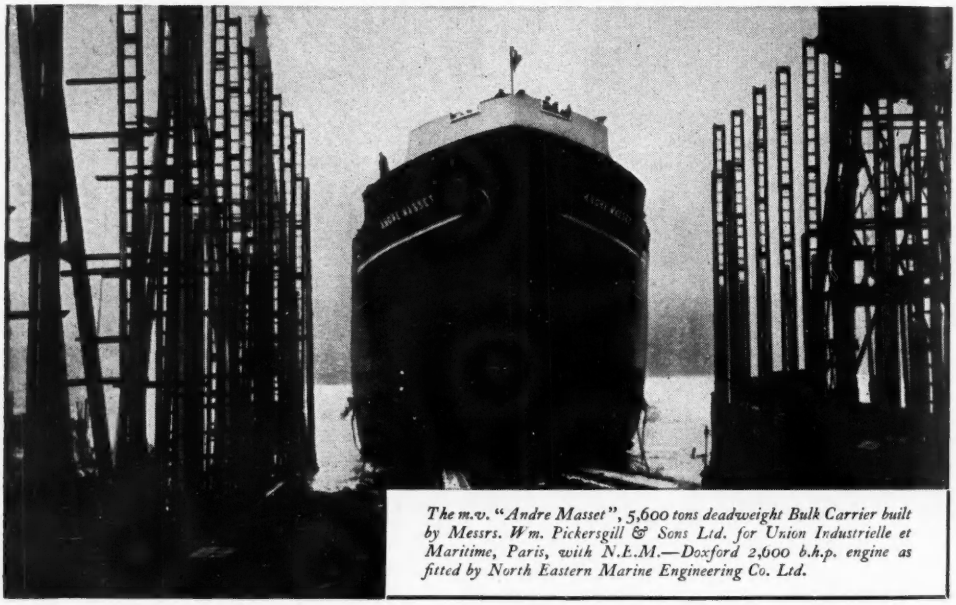
On the m.v. *"Andre Masset"*

Stern tube bearings, rudder bearings and generator mountings— all of long life **TUFNOL**



The m.v. "Andre Masset", 5,600 tons deadweight Bulk Carrier built by Messrs. Wm. Pickersgill & Sons Ltd. for Union Industrielle et Maritime, Paris, with N.E.M.—Doxford 2,600 b.h.p. engine as fitted by North Eastern Marine Engineering Co. Ltd.

The "Andre Masset" is one of the many ocean going vessels whose owners and builders recognise the long life properties of TUFNOL. On this ship, stern tube bearings, rudder bearings and generator mountings are all of TUFNOL.

Some of the advantages of TUFNOL

1. Long life
2. Low water absorption
3. Small dimensional change
4. Can be stored indefinitely—no special precautions are necessary
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6. Available in sheet, tube and rod to suit exact requirements
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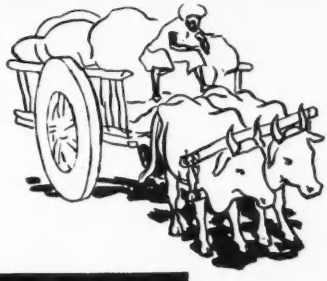
Mirrlees Diesel Power for Pakistan



To provide immediate power in Pakistan, pending the long-term development of hydro-electric schemes, the government has installed a number of diesel generating stations. Many of these stations are equipped with Mirrlees Diesels—since 1949 a total of 60,000 B.H.P. at-site has been ordered.

The largest and most recent station to be completed in West Pakistan is at Lyallpur with six Mirrlees/Brush KVS-12 generating sets each developing 1777 B.H.P./1242 kW continuously on site.

These engines are backed by Mirrlees world-wide service, available anywhere at any time.

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diesels

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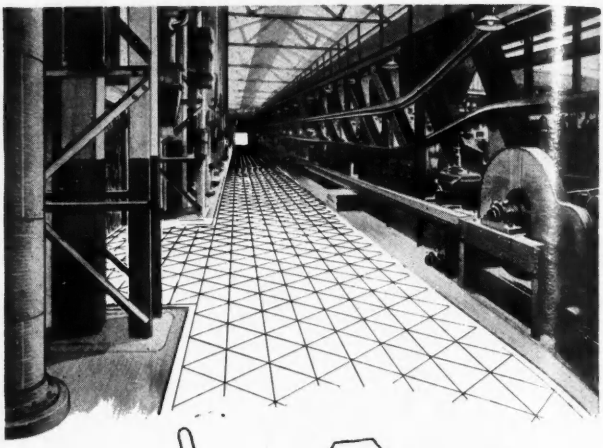

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Crazy paving is attractive in the right setting — but not in factories. Danger lurks in every crevice of badly laid flooring — danger to operatives and possible damage to equipment. A flooring which is speedily laid, mechanically level and above all, safe for *all* traffic is the Tri-Pedal Unit System of Iron Paving. It provides a permanent system of flooring which will stand up to the heavy wear and tear experienced in workshops and factories. Complete details of the Tri-Pedal System will be supplied on request.

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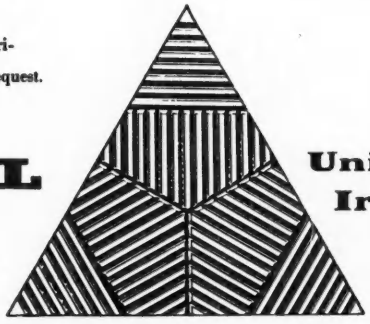

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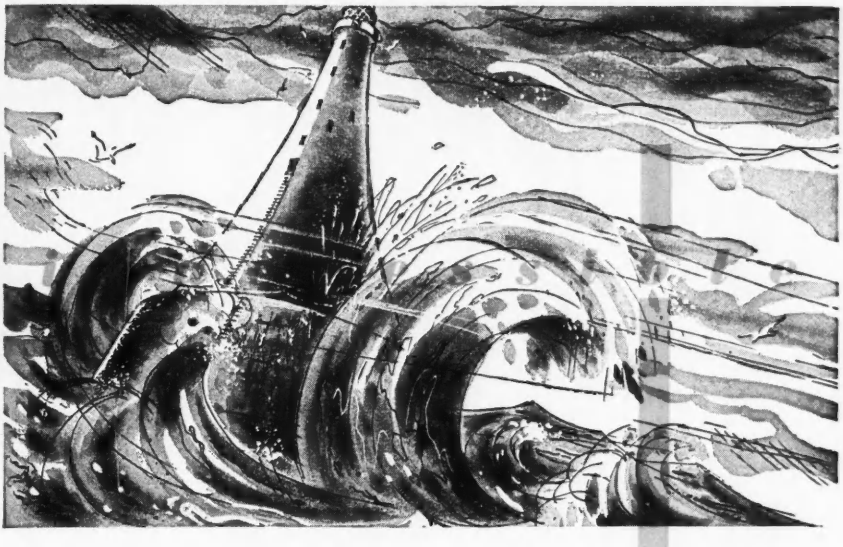

The Lighthouse, *proud guide over the storm ravaged ocean and warning sentinel against the lethal power of rock and current, lights up the problems of inaccessibility. These problems are more easily solved in industry and the home, in equipment where maintenance for lubrication is difficult or undesirable, by the use of "Reservoil" sintered-metal oil-retaining bearings. With these, oil is fed by capillary action to the bearing surface, providing trouble-free lubrication automatically.*

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Machine Tools are an instance where "Reservoil" bearings are used to advantage. These bearings are supplied in shapes and sizes for every normal medium duty, but attention is drawn to the standard range of plain cylindrical bearings. Write for Catalogue SD41.

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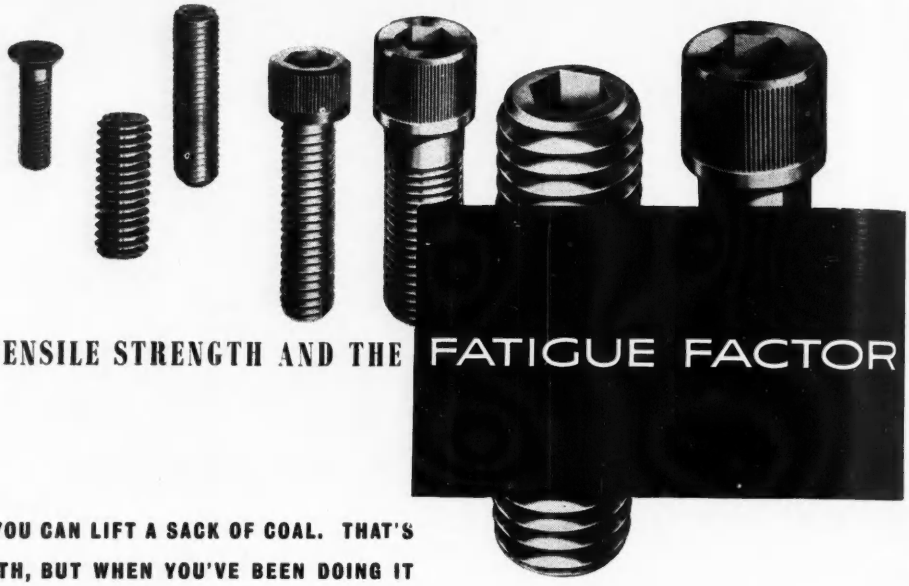
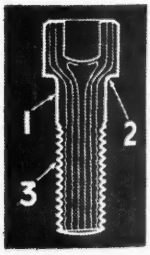


TENSILE STRENGTH AND THE FATIGUE FACTOR

MAYBE YOU CAN LIFT A SACK OF COAL. THAT'S STRENGTH, BUT WHEN YOU'VE BEEN DOING IT ALL DAY, THAT'S FATIGUE.

It has always been an easy matter to show a high Rockwell reading of hardness by merely heat treating any one of many varied steels. These steels may show up splendidly in a tensile test, but are completely worthless on today's higher speed machines and heavier stress forming service conditions. Why are they worthless? They have no fatigue life. Fatigue is a factor which has only received full consideration in recent years. It simply means that metal gets tired and gives way under continual stress, as when you bend a piece of wire back and forth until it breaks.

Unbrako technicians constantly strive to achieve the perfect balance between tensile strength and fatigue resistance. That is why Unbrako use only best quality Alloy Steel to their own exacting specifications, and make screws to the highest possible standards of unvarying precision. At the trouble spot under the head (1) *Unbrako have a fatigue-resisting fillet. At the thread root* (3), *fatigue resistance is greatly increased by the continuous closely-knit grain flow and rolled thread* (2) *and superior notch-free surface finish. No doubt, Unbrako make the world's finest screws and you can specify them with confidence. May we send you fuller details?*



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THE UNBRAKO SOCKET SCREW COMPANY LIMITED · COVENTRY

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Our magnets are really better behaved than this. In fact, they are almost indispensable if you wish to move iron and steel about, and at the same time cut the cost of doing so. If you are looking for a "lift" in production our publication No. 116 will tell you how to do it.

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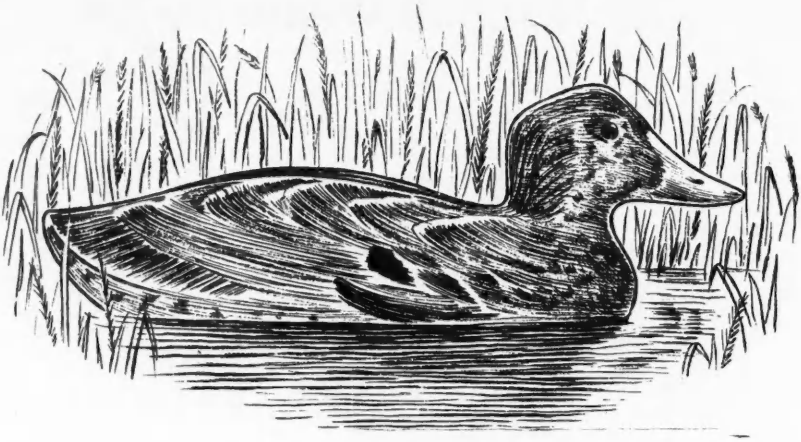

decoy duck

What an efficient foil the duck decoy has proved to be.

Its realistic crafting makes it quite indistinguishable from the " real thing " even at very short distances—at least the keen eyes of

" brother duck " are completely deceived, much to the joy of the sporting fraternity.

Even to the experienced eye a variety of castings may look alike. Only when they are put to their particular task is the strength or weakness visible.

Ycol castings in gunmetal, phosphor bronze, manganese bronze, aluminium bronze and aluminium alloy have gained an enviable reputation for purity, uniformity and durability. Every care is taken through every phase of their manufacture, in a modern foundry planned specifically for the production of high quality castings.

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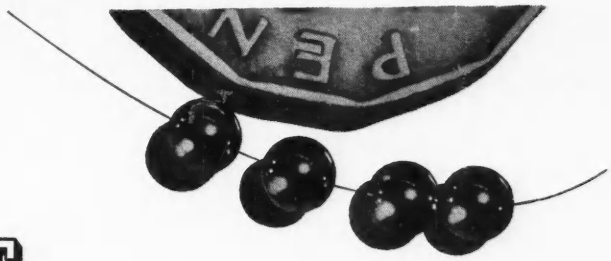
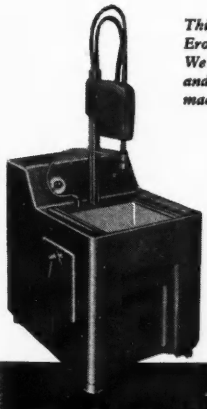


TOP SECRET

Although tooling engineers have been quick to assess the possibilities inherent in the spark machining process and many interesting applications have become evident as a result, frequently there is a reluctance on their part to talk about these successes, or allow us to do so. For the march which spark-machining has helped them to steal on their competitors is a substantial one — too valuable, in fact, to give away.

Frequently (and fortunately) interesting exempted applications are proven from time to time, which can serve to illustrate some aspects of the process.

Hole drilling is probably the commonest and most normal of metal-working operations. It poses some problems, however, when the hole required is only 0.008" diameter, and to be produced in hardened steel, and through a ball bearing at that! Spark machining solved this "insoluble" problem for The Sperry Gyroscope Co. and resulted in consistently accurate drilling on a production basis.



This is the type W/SM Erodomatic Machine. We also make a larger and even more versatile machine, Type W/UV.

This press tool die for piercing motor-car radiator top tank covers, illustrates the effectiveness of the process for multi-impression work. A total of 114 slots, each $\frac{5}{8}$" long by $\frac{1}{10}$" wide and $\frac{5}{8}$" deep were pierced in hardened tool steel in less than 24 hours machine time. It was produced on the small Wickman Erodomatic with only intermittent inspection by the operator during the erosion process.

Once set-up and erosion begun, the Wickman Erodomatic operates automatically and continuously until the operation is finished.

These are just two of the many ways in which the spark-machining process is cutting costs and achieving the impossible.

Let us tell you more about the process. We have published a booklet which describes it, and some of the more interesting applications we have engineered. Ask us to send you a copy.

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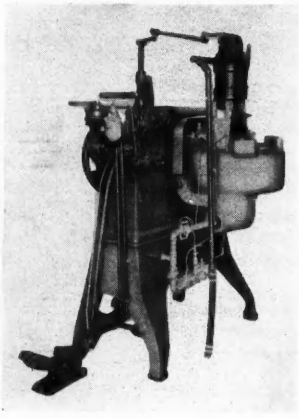
Model No. 215



Higher Production

Lower Costs

1½ lb. Capacity in Zinc

YOU PRODUCE MUCH FASTER WHEN YOU INSTALL A KIPPCASTER

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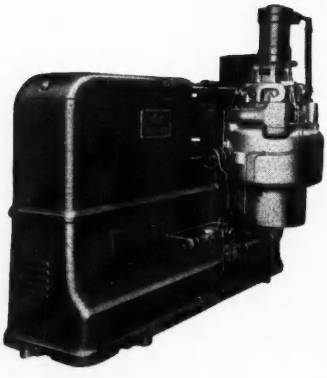

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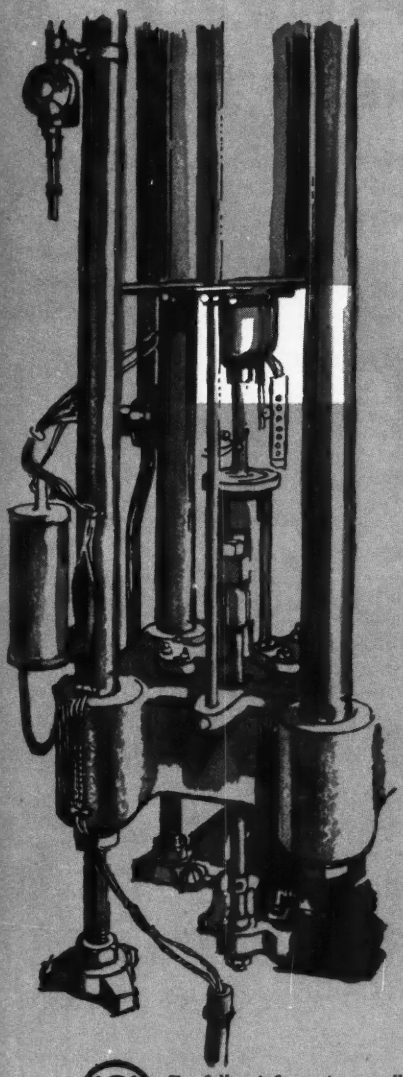
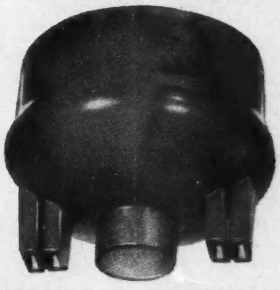


The United Kingdom Atomic Energy Authority were faced with an unusual problem when creep-testing some of their materials. How could they exclude the atmosphere, at test temperatures, in the region of the specimens, and still allow sensitive measurements to be made? Once again, I.C.I. silicone elastomers provided a solution. The Dunlop Rubber Company designed and produced a special extensometer seal of I.C.I. Silicone rubber which prevented the atmosphere entering the furnace tube in which the test specimens were shackled. The elasticity of the silicone rubber allowed sensitive measuring instruments to pass through the seal without restriction even though temperatures of up to 200°C were attained. This combination of elasticity and temperature resistance is an outstanding feature of I.C.I. silicone rubbers — one which can very likely solve a problem for you.



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—material progress

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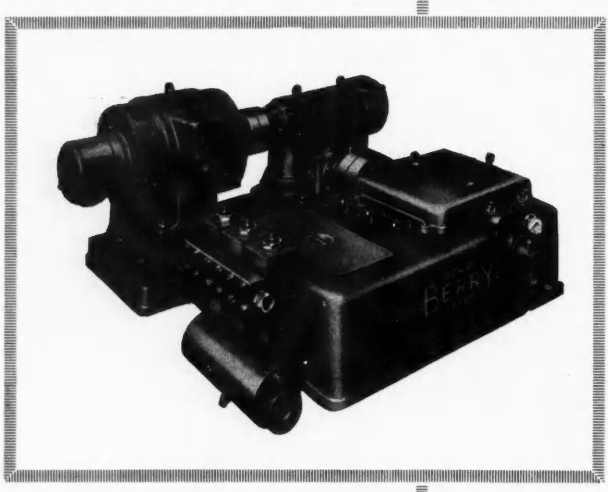
M.S.49

HORIZONTAL HYDRAULIC PRESSURE PUMP

by HENRY BERRY



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Strength Rigidity

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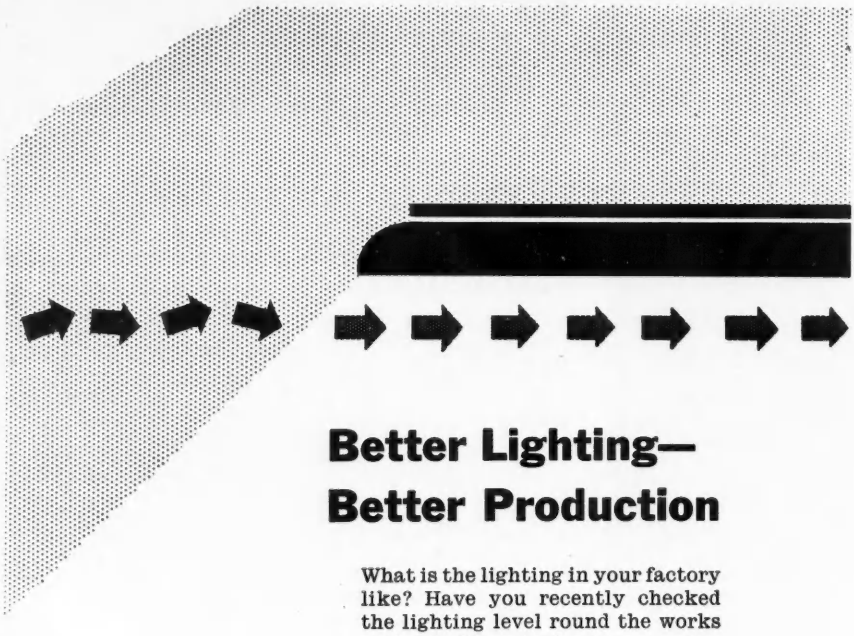

Better Lighting—Better Production

What is the lighting in your factory like? Have you recently checked the lighting level round the works with a light meter?

The *right* lighting has a significant effect on the speed and accuracy of production. When its strength, position and type is suitable for each job the craftsman can give full play to his skill, and the works engineer can do full justice to his shop.

Good lighting is only one of the many ways in which electricity is playing a vital part in the drive for higher productivity.

Electricity for Productivity

Ask your ELECTRICITY BOARD for advice and information, or get in touch with E.D.A. They can lend you, without charge, films about the uses of electricity in industry. E.D.A. are also publishing a series of books on Electricity and Productivity. Titles now available are: Electric Motors and Controls, Higher Production, Lighting in Industry, Materials Handling, and Resistance Heating. Price 8/6, or 9/- post free.

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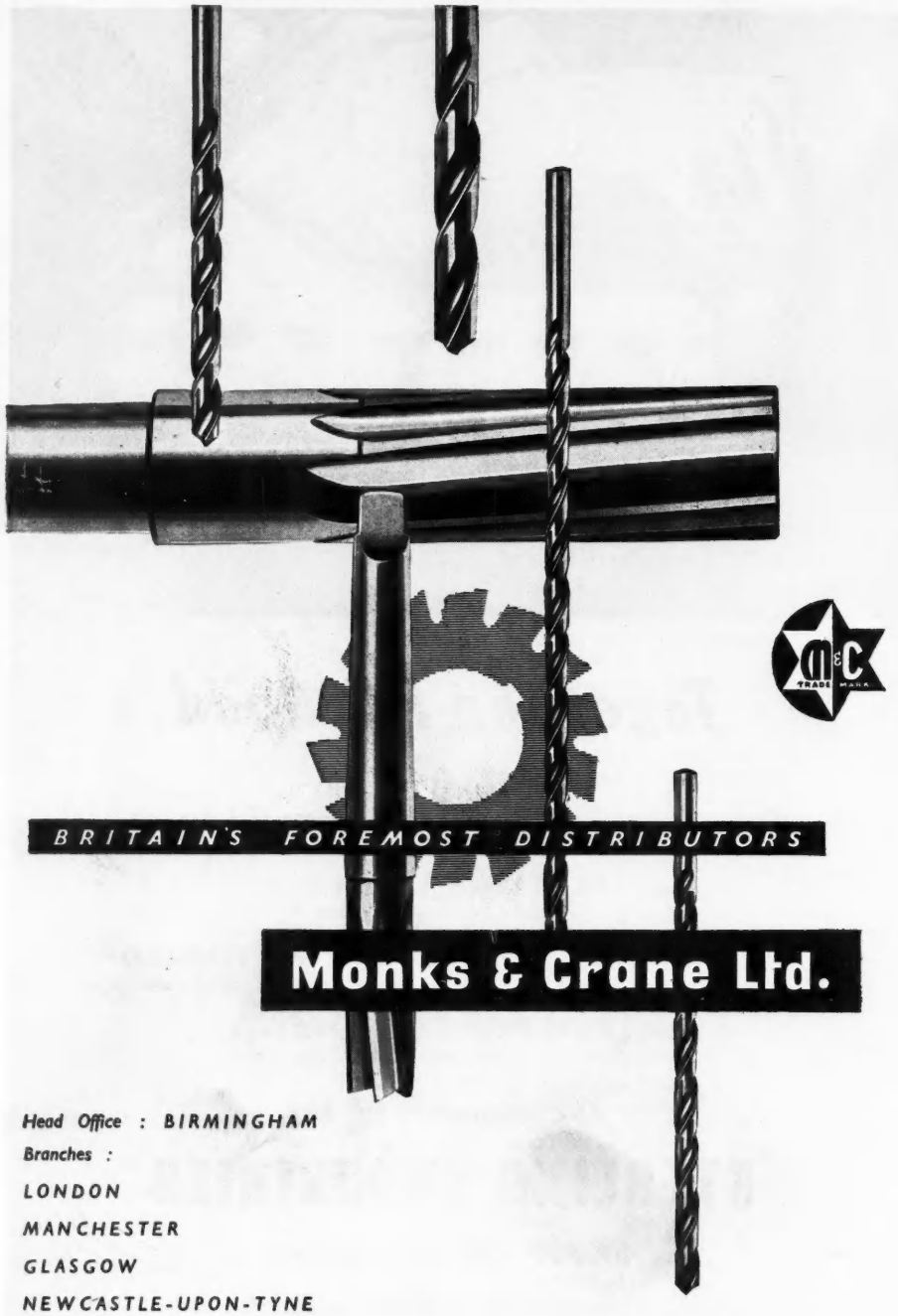
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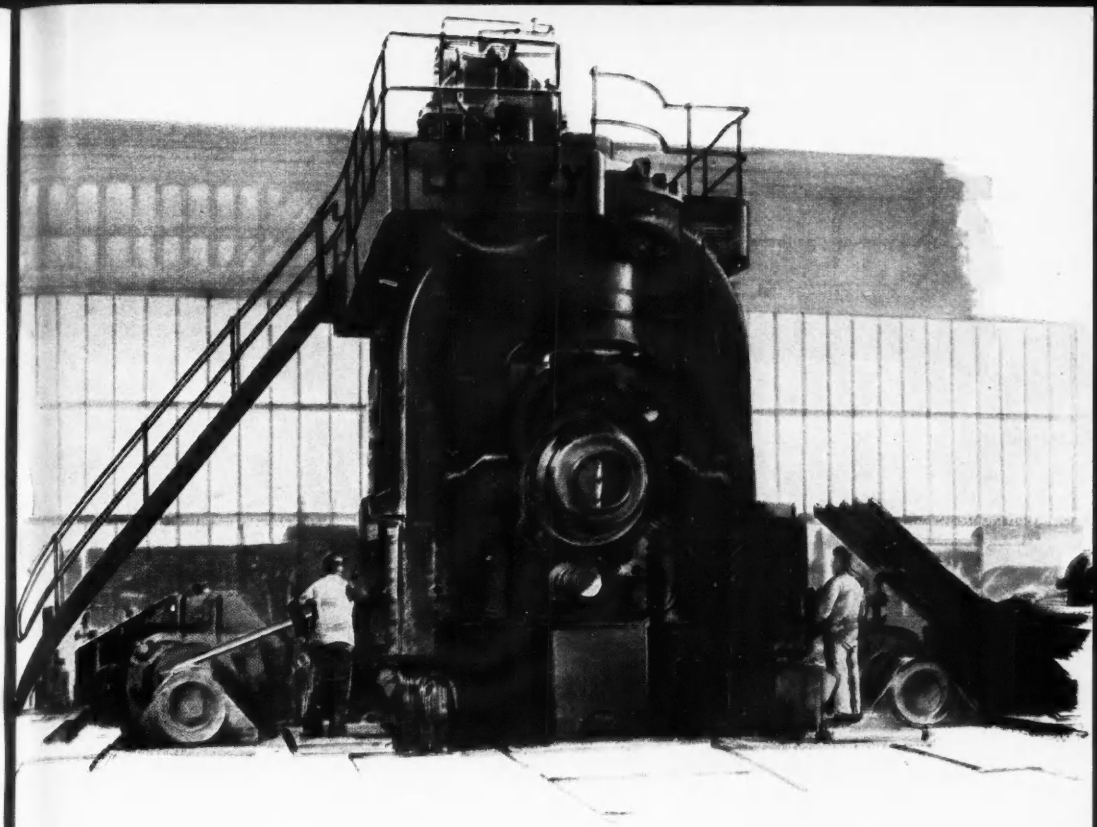
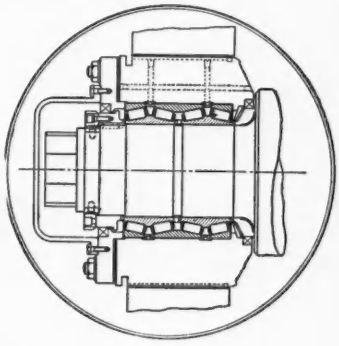


Built in Great Britain For Export

The artist's impression shows the 20½" and 55" x 88" 4-high Cold Reversing Mill for wide steel strip built for France by The Loewy Engineering Company Limited, London. This mill is equipped with Timken balanced-proportion tapered-roller bearings on the back-up and work rolls.

MADE IN ENGLAND



TIMKEN

tapered-roller bearings

REGD. TRADE MARK: TIMKEN

Our manual on Rolling Mill and Steelworks Equipment, illustrating many installations of Timken tapered-roller bearings, will be sent on request.

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THE GOODYEAR TYRE & RUBBER CO. (G.B.) LTD · INDUSTRIAL RUBBER PRODUCTS DEPT · WOLVERHAMPTON

This obviously should be a rubber moulding.
I'm not so sure— it might be better in plastic. Let's ask R.I.L., they will tell us, —they do both!

THE reputation gained over the years by Rubber Improvement Ltd. is such that Purchasing Officers throughout industry call us in automatically when rubber, flexible or semi rigid, mouldings are required. It is recognised that our team of technicians and our modern manufacturing plant ensure an accurate and well finished product to meet the most stringent specification.

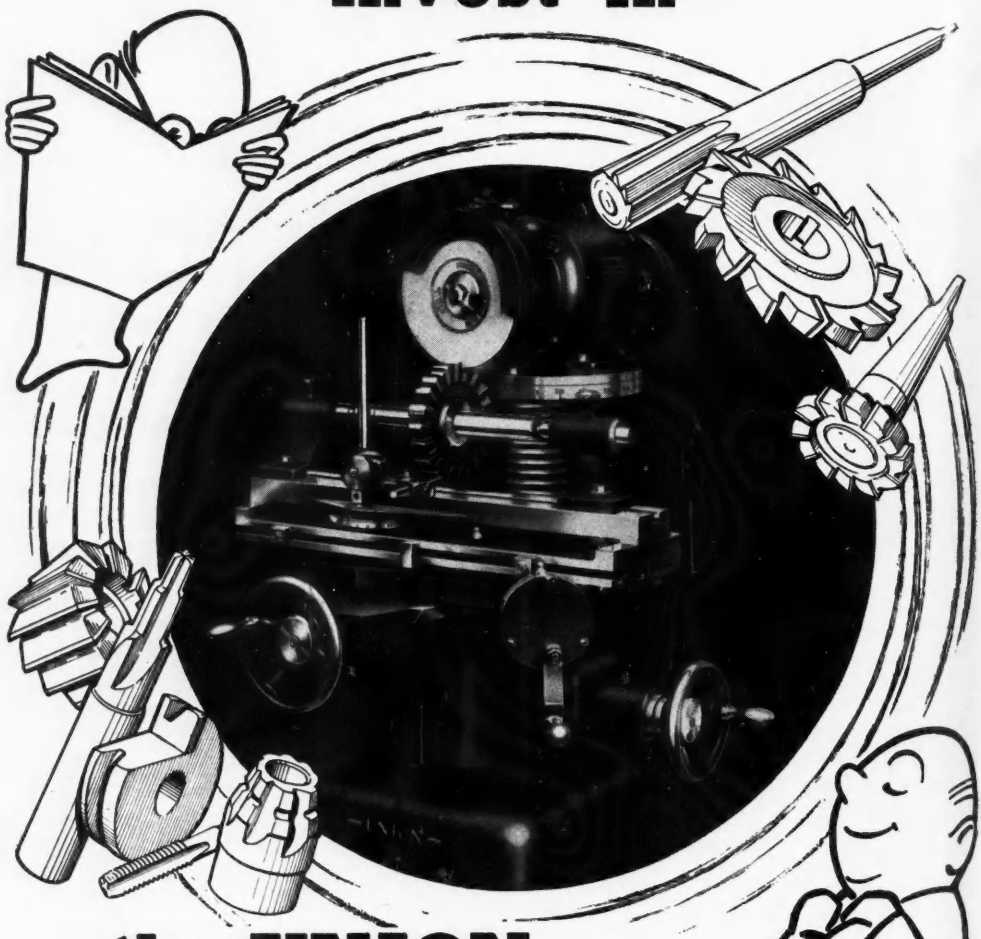
The services of our Technical Staff and the Research and Development Centre are readily available to assist in the solution of any problem.

RIL

RUBBER IMPROVEMENT LTD., WELLINGBOROUGH, NORTHANTS

Tel: Wellingborough 2218

invest in



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a real asset to greater production

Correct tool grinding reduces tool costs, improves rates of production and gives better quality finish. Infrequent grinding invariably causes heavy tool wear and consequent reduction of tool and grinding wheel life.
A Union Tool and Cutter Grinder in your plant is a good investment.

UNION
TOOL AND CUTTER GRINDERS

Send for fully detailed leaflet, TODAY!

T. S. HARRISON & SONS LIMITED, Heckmondwike, Yorkshire

Parker Progress

a new 45 ton per hour sand rammer

Parker marches on! New plant, new buildings, new processes are helping Parker craftsmen to give you even better Steel Castings. The whole layout has been re-schemed for the continuous flow production of low carbon steel castings with high magnetic permeability and pearlite manganese steel castings requiring high tensility and exceptional wearing characteristics.

One example of Parker progress is the tractive type Speedslinger ramming machine illustrated above. It is the world's latest type and one operator mounted jockey wise on the ramming head, can traverse and ram moulds situated anywhere within 20 ft. of his track, at the enormous rate of 45 tons of sand per hour!

PARKER

steel castings

Manganese, Carbon & Alloy Steel.

PARKER FOUNDRY (1929) LTD., MANSFIELD ROAD, DERBY · TELEPHONE: DERBY 44243

A Print for Industry Ltd. Advertisement

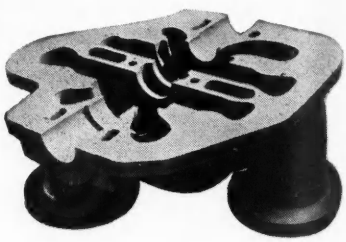
'Two birds with one stone'

OR—machine your components where they are cast

The proof of a casting lies in the machining. In this respect, Lloyds have unique on-the-spot facilities for machining castings made in their own foundry. This service operates to the advantage of the customer.

When an order is placed with Lloyds for casting and machining, the two operations are co-ordinated and treated as one production job. Casting methods are prepared for jigging, important faces are given special care in the foundry and the finished product benefits by an integrated system of quality control.

Lloyds also have extensive capacity for proof machining or high precision finish machining. Lloyds machine shops represents the best in highly skilled personnel and modern equipment that the renowned Midlands can offer.



PUMP BODY, *weight 1,230 lbs., dimension 2' 11½" x 2' 8" x 1' 8½" Cast for Sigmund Pumps Ltd.*

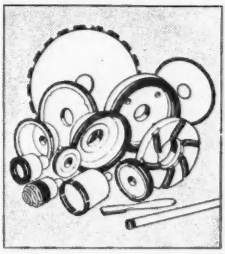
A Print for Industry Ltd advertisement

LLOYDS

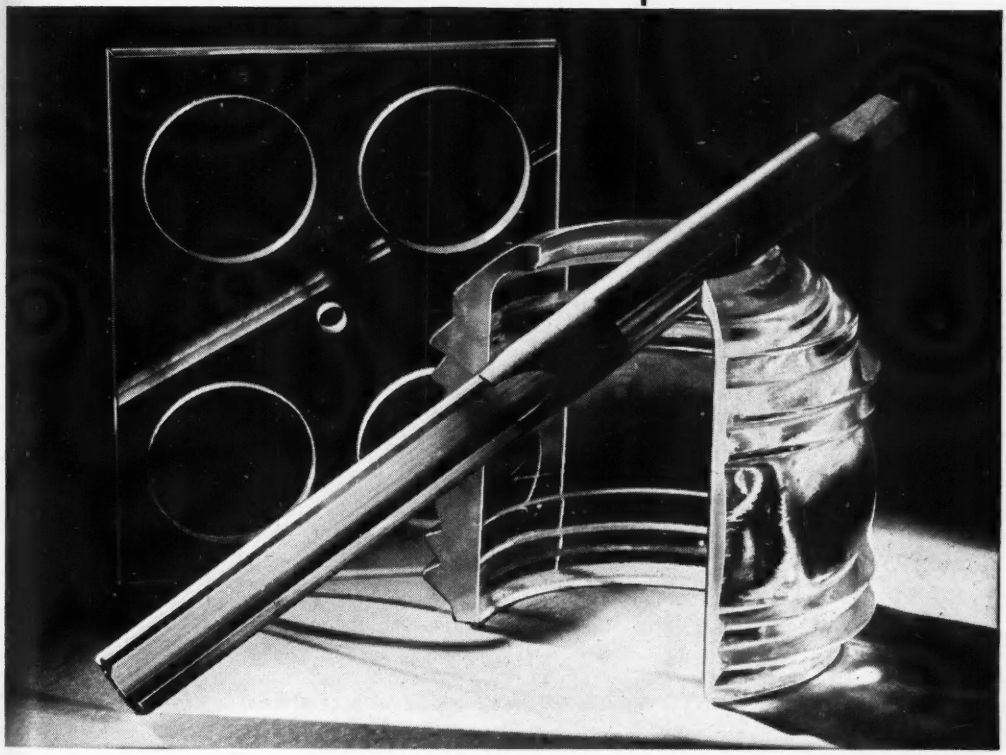
Britain's Best Equipped Steel Foundry

P. H. LLOYD & COMPANY LTD., P.O. BOX 5 JAMES BRIDGE STEEL WORKS DARLASTON JAMES BRIDGE 2401

NEVEN *Diamond* TOOLS



cut, drill or grind any hard material



CERAMICS, TUNGSTEN CARBIDE, GLASS, QUARTZ, STONE, GRANITE
MINERALS, SLATE, SHELL, REFRACTORIES AND ALL HARD METALS

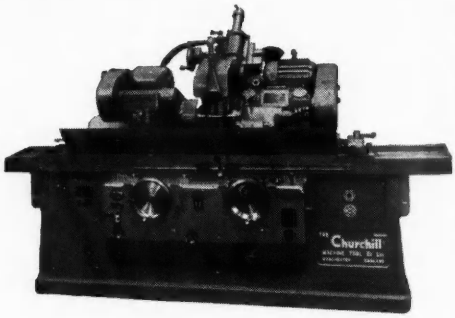
IMPREGNATED DIAMOND PRODUCTS LTD·GLOUCESTER

Telephone 21164·Telegrams·Impreg·Gloucester.

Churchill

The CHURCHILL model 'BW' 10in. swing Plain Grinding Machine has a reputation for accuracy and high output. The machine shown here is equipped with twin grinding wheels for grinding two diameters simultaneously. The wheel forming device is mounted permanently on the back of the wheelhead and enables the wheels to be trued in correct relationship to the finished work diameters.

The 'BW' Machine can be supplied as a non-automatic or fully automatic Plain Grinder.



THE CHURCHILL MACHINE TOOL CO. LTD., BROADHEATH, NR. MANCHESTER

Export Sales Organisation:
Associated British Machine Tool Makers Ltd., London. Branches and Agents

Home Selling Agents:
Charles Churchill & Co. Ltd., Birmingham and Branches.

PRECISION *plus* PRODUCTION

C639A

Drop Forging a Gas Turbine Compressor Disc

DROP FORGINGS

IN ALLOY & CREEP-RESISTING STEELS, "NIMONIC" & TITANIUM ALLOYS

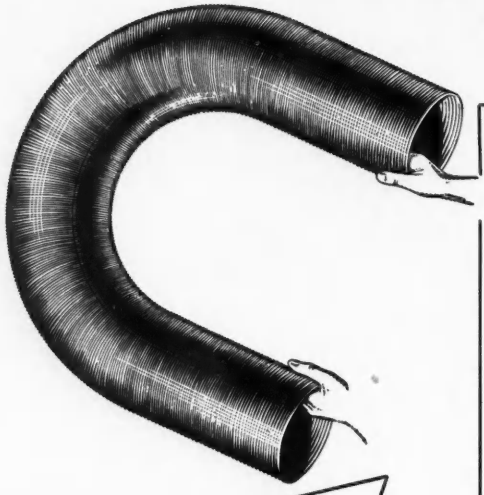
by

FIRTH-DERIHON

THE FIRTH-DERIHON STAMPINGS LTD · TINSLEY · SHEFFIELD

KOPEX PLIABLE DUCTING

Can be bent, set and cut by hand



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GRADES FOR ALL CONDITIONS

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Straights or
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Undistorted Bore

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Up to 7½" I.D.

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In Metal-Paper or
All Metal

FULL TECHNICAL DATA FROM

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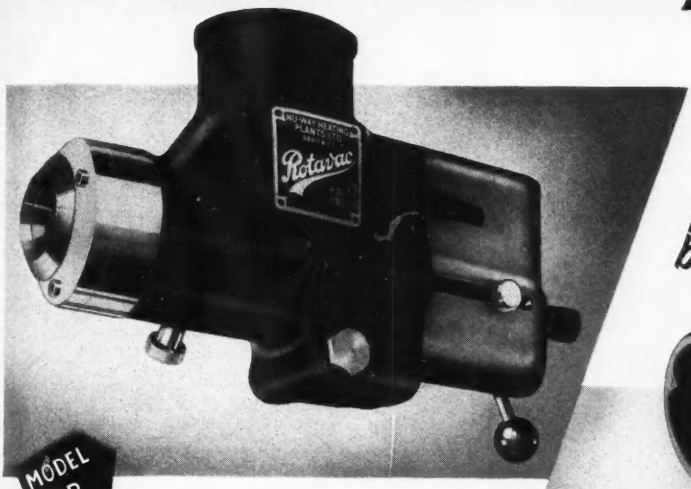
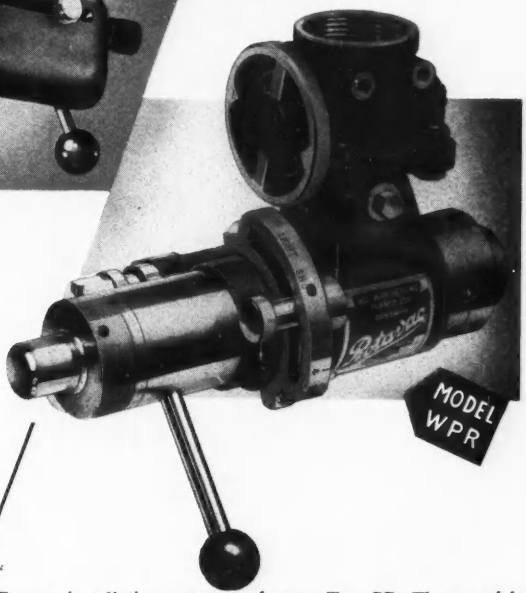
Cut OIL consumption

on your furnaces with these **ROTAVAC** proportioning burners





assure

1. *Greater fuel economy.*
2. *Most accurate control of combustion and temperature.*
3. *Better heating uniformity.*

eliminate

1. *Guesswork on air-oil ratios.*
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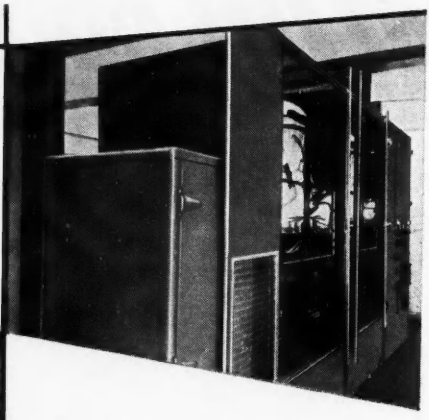
For new installations—Rotavac burners Type PR. Three models, nine nozzle capacities (from 3 imperial gallons/hr. maximum to 17 imperial gallons/hr. maximum at 25" w.g. air pressure). For existing Rotavac installations, where suitable—Rotavac conversion inner assemblies type WPR. Four models to convert standard Rotavac models W, W2, W3 and W4 without alteration of pipework.

Nu-way

NU-WAY HEATING PLANTS LTD. (BOX 630), DROITWICH.
And at London, Manchester, Glasgow, Belfast, Newcastle, Dublin, Bristol.

EVERYWHERE AND ANYWHERE

Hewittic Rectifiers give reliable service . . .



The robustness, lightness, and manœuvrability of Hewittic Rectifiers make them ideal for installation in awkward situations, and their outstanding operational characteristics, proved over a period of 50 years, ensure utmost reliability and long service.

For every type of A.C.-D.C. application and from the smallest sizes up to any capacity.

★ *The photographs show a 300 kW. Hewittic Rectifier substation in mining traction service in Mexico.*

Hewittic Rectifiers

OVER 1½ MILLION KW. IN WORLD WIDE SERVICE

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WALTON-ON-THAMES - SURREY - ENGLAND
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HEAVY DUTY VERTICALS

for drilling up to 4" in steel!

THIS photograph, taken at the Lincoln Works of Ruston Bucyrus Ltd., shows their wise choice in selecting ARCHDALE for heavy duty vertical drilling machines. Built with a strength and rigidity to match the power required for continuous heavy work, these machines will drill up to 4 in. dia., in M.S., the 30 in. machine, 3 in. dia., and the 28 in. machine 1¾ in. dia. All three can be supplied with plain, elevating or compound tables.

JAMES ARCHDALE & CO LTD · LEDSAM STREET · BIRMINGHAM 16

SOLE AGENT: ALFRED HERBERT LTD, COVENTRY

STOP! to think

STOP to think about it and there's more to this Pressure Gauge business than meets the eye. That's why the more fastidious users are specifying P & G Gauges. They *are very* dependable for a very long time.

P & G supply quality instruments for accurate measurement of low pressures; with specially constructed diaphragm or bellows.

The gauge illustrated is No. 34 diaphragm type pressure or vacuum gauge for pressure as low as a few inches of water column. Available for surface, direct or flush panel mounting.

Stop to think of Pressure Gauges and think of P & G Illustrated catalogue No. 52 sent on request.

Payne & Griffiths Ltd

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TUDOR WORKS, WINDMILL LANE
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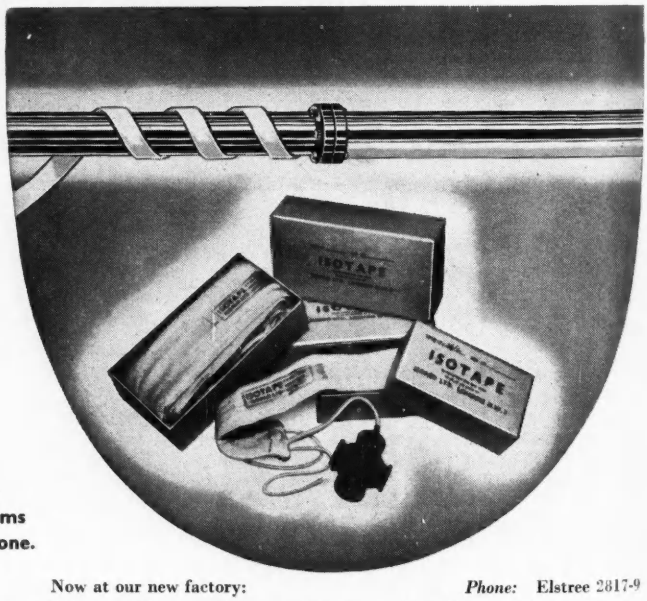
SM/PG 2719

Isotape Electric Heating Tape

Thousands of these flexible, fully insulated units are in daily use maintaining pipelines at elevated temperatures—up to 400°C. (750°F.), heating columns, valves and vessels. They ensure a free flow of viscous materials such as fuel oil, chemicals, food products, chocolate, etc.

Standard sizes: 1, 2, 3 and 4 inch widths, from 3 ft. up to 70 ft. lengths. Also waterproof type ITO, up to 80°C, and type ITW up to 220°C.

Catalogues on request.



Our Design Department is at your service for solving special problems —let us have your particular one.

Isopad Ltd.

Now at our new factory: *Phone:* Elstree 2817-9
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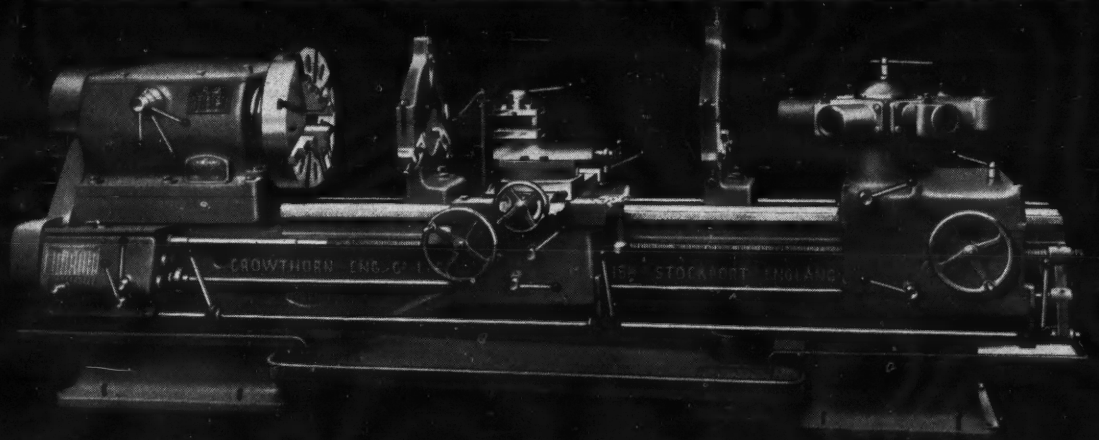
12½" CENTRE COMBINATION TURRET LATHE



In addition to the model shown we can supply other sizes fitted with heavily built hexagon turret on separate power operated carriage or alternatively in place of the square toolpost.
A machine similar to that shown was supplied to Messrs. W. Sisson & Co. Ltd. of Gloucester for machining engine yokes, etc.

- ★ Swing over bed: 25"
- ★ Swing in gap: 39" × 12"
- ★ Hole through spindle: 3⅛", diameter
- ★ Bed length: To customers' requirements
- ★ Spindle speed ranges: 10½ to 302 or 15 to 453 r.p.m.
- ★ Inverted vee type slideways
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- ★ Built for accuracy and heavy duty

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HIGH CLASS MACHINE TOOL MAKERS

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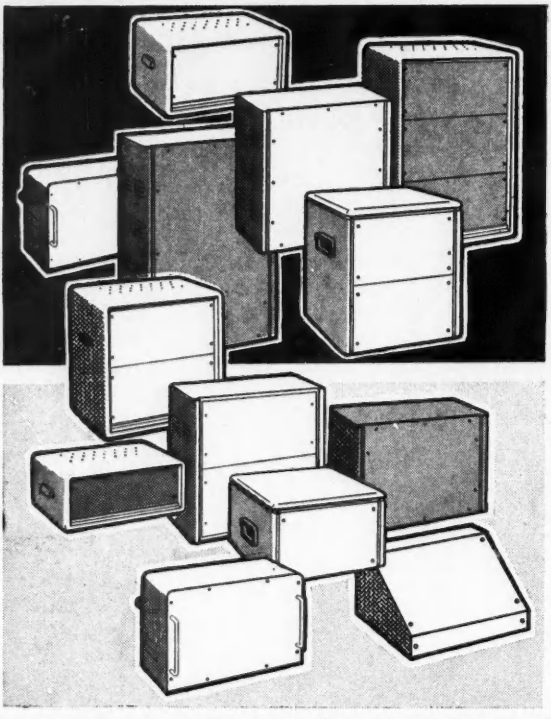

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fifty instrument cases seven days delivery

In actual fact, 99 per cent of the orders received for standard cases at our new Uxbridge factory are now completed well within this time. And, where specially requested, this delivery can be improved upon. We also make special cases from your own drawings—though naturally these take a little longer to produce.

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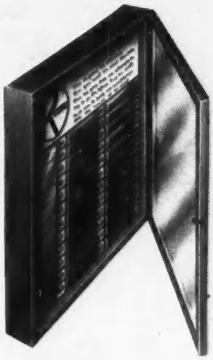
Horstmann Precision Gauges are guaranteed for accuracy, hardness and finish to the requirements laid down by the National Physical Laboratory. A full range of screw or plain Plug and Ring types is available as well as the Patent CALIPER GAUGE, Model 52. This gauge embodies features which ensure easy handling and speedy accurate measuring. It is particularly suitable for shouldered work.

Send to-day for descriptive leaflets.

HORSTMANN **THE HORSTMANN GEAR CO. LTD.,**
Newbridge Works, Bath. Tel: 7241



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Surface Roughness Scales

(Accuracies: 5%, 10% or 20%)

are already used by hundreds of the most prominent British Firms.

They provide a reference of calibrated Surface roughness for comparing machined surfaces by sight and touch from 4 to 1000 micro" C.L.A. according to B.S. 1134 : 1950.

They fulfil the need for a simple, dependable standard for visualising, selecting and specifying surface conditions for production work.

We also supply Pocket Size Sets composing 10 stainless steel specimens from 4 to 500 micro" C.L.A. and single specimens 1 in. by $\frac{5}{8}$ in. by $\frac{3}{8}$ in. and Cylindrical Standards to B.S. 2634/1.

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Over and over again a few minutes' work with a Heli-Coil Kit will save costly work from scrap. No shop can achieve maximum output unless Heli-Coil is part of its equipment. The technique is rapid, simple and highly efficient.

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SCREW THREAD INSERT KIT

* REGD. TRADE MARK.

Contact your main distributor to-day

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ARMSTRONG PATENTS CO. LIMITED BEVERLEY YORKSHIRE

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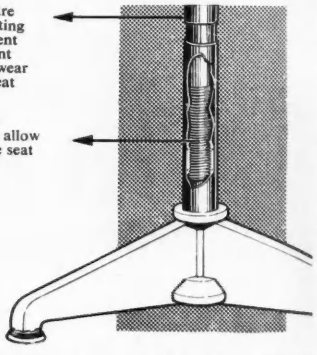
All Steel OFFICE CHAIR

UTILITY PLUS EXTRA COMFORT

NOW FITTED WITH IMMERSED CENTRE SCREW

" Oil immersed " centre screw and self-lubricating bush provide permanent lubrication and prevent squeaking. Reduces wear giving added life to seat adjustment.

Fine cut screw thread allow fine adjustment to the seat height.



PLUS OTHER NEW EXCLUSIVE FEATURES

Both seat and back rest are mounted on a scientifically designed steel pan which retains its shape throughout the life of the chair. Seat and back rest are both padded with Latex Foam interlay which in turn are covered and fitted with " Lip Grip " bead (Pat. applied for).

Write for catalogue No: W.1.

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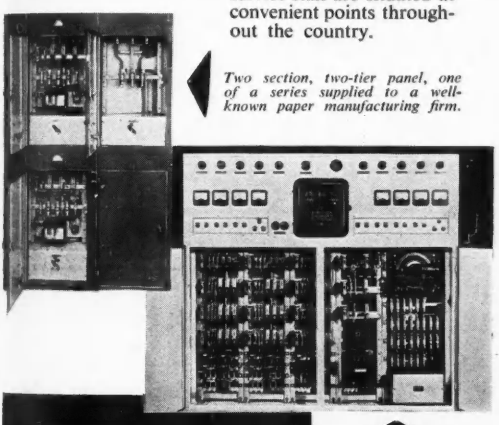
WALSALL ROAD, PERRY BARR, BIRMINGHAM, 22b.

London Office: Kern House, Kingsway, W.C.2.

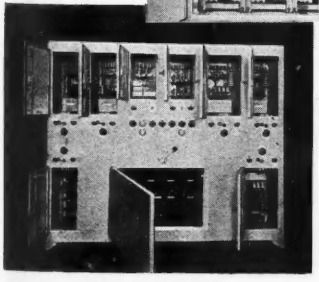
GWB

Control Panels for special purposes

G.W.B. design and supply centralised control panels for many industrial applications. Available in a variety of forms, these panels conform to the most stringent specifications. Contactors, relays and isolators controlling individual machines are contained within separate compartments, and all maintenance and replacement of contactors and ancillaries may be carried out from the front. G.W.B. engineers are available for the solution of circuit problems and any special operational requirements. Sales and service staff are situated at convenient points throughout the country.



Two section, two-tier panel, one of a series supplied to a well-known paper manufacturing firm.



Special purpose panel supplied for the control of an automatic brickmaking plant.

Multi-motor control panel with individual compartment and isolation for each motor starter; supplied to a large synthetic fibre manufacturing concern.

All contactors are made to the famous G.W.B. standards. Among the many refinements making them pre-eminent in their field are:

- **Sintered Tungsten-Silver contacts for LONG LIFE**
- **Open type construction for EASY MAINTENANCE**
- **Special coil design giving LOW CURRENT ABSORPTION**

G.W.B. Low Tension control gear 10—1,400 amps A.C. & D.C.

G.W.B. FURNACES LTD

Control Gear Division

P.O. BOX 4, DIBDALE WORKS, DUDLEY, WORCS

Telephone No. DUDLEY 4294 Telegrams: GIBWILDBAR, DUDLEY

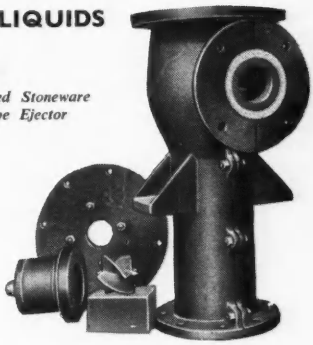
Proprietors: Gibbons Bros. Ltd. & Wild-Barfield Electric Furnaces Ltd. GWB407

STONEWARE

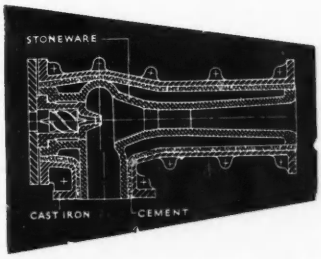
EJECTORS

for HEATING & CIRCULATING CORROSIVE LIQUIDS AND GASES

Armoured Stoneware Swirl-type Ejector



HATHERNWARE EJECTORS are made of high-grade Hathernware Chemical Stoneware, with steel or iron armouring as required. The adoption of Chemical Stoneware for these instruments adds greatly to their usefulness in the Chemical and allied trades, as Hathernware is proof against the attack of practically all industrial acids and corrosive liquors at all concentrations and temperatures.



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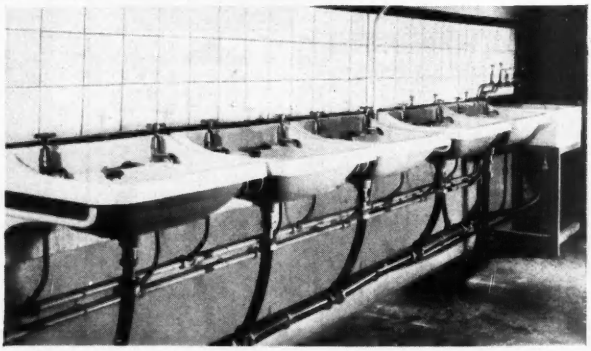

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P.P. 12

Facts about Porto-Power

Applications of Hydraulic Equipment

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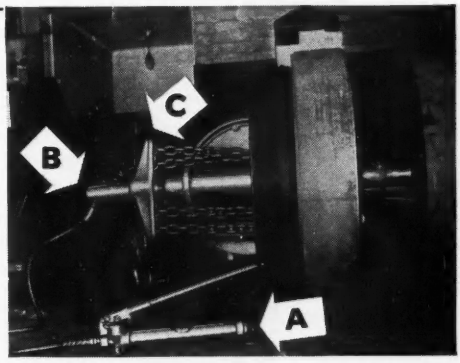

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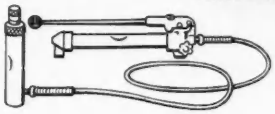

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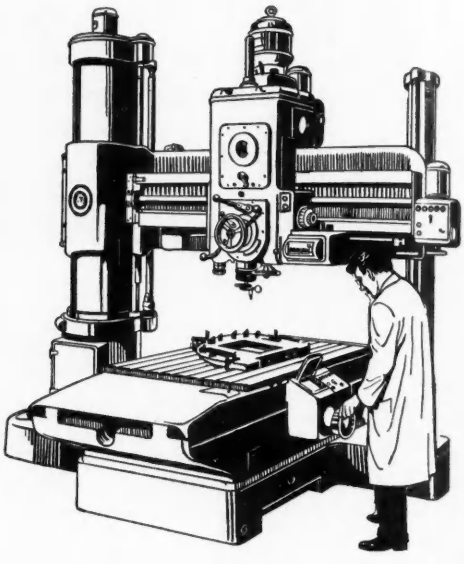

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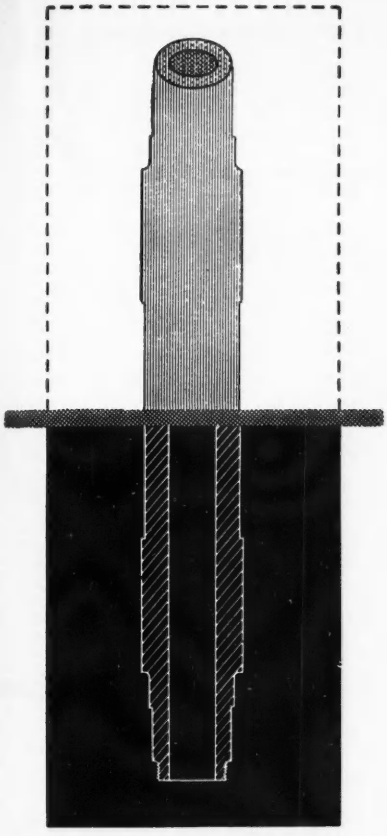

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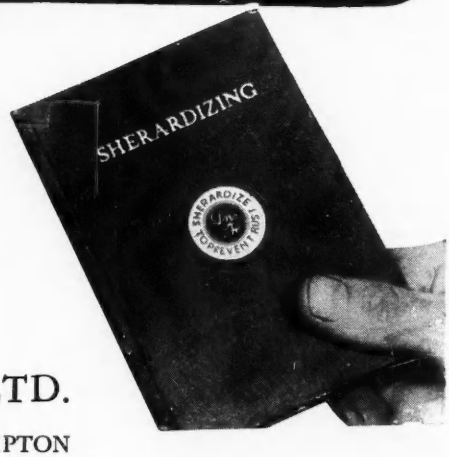

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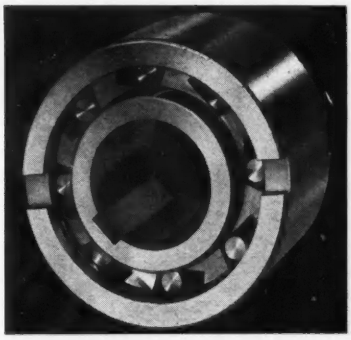

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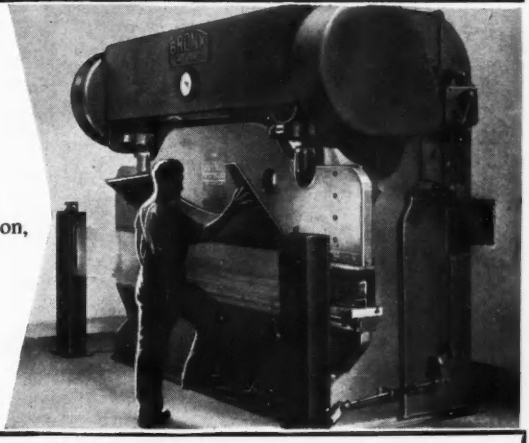

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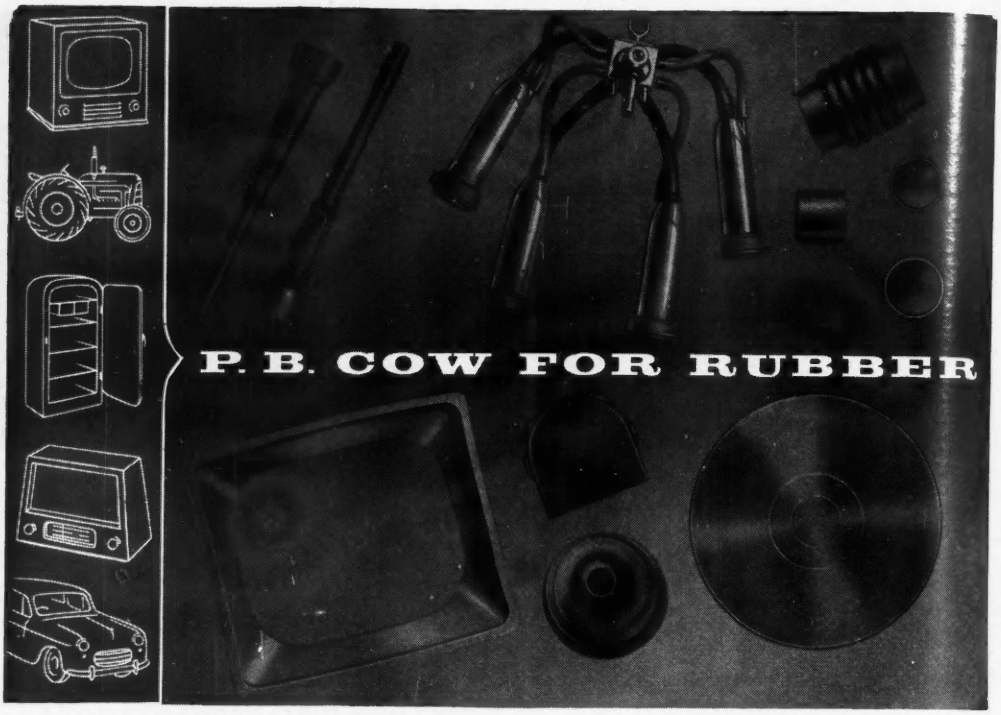

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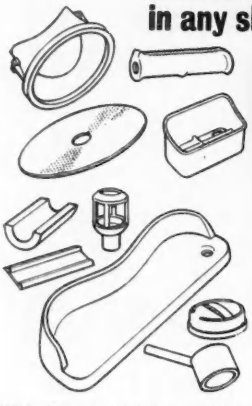

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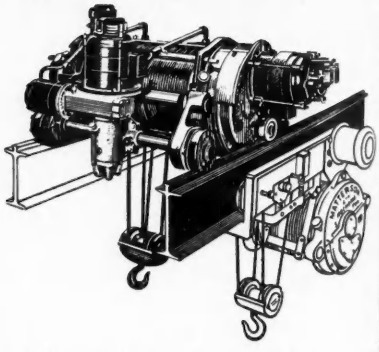

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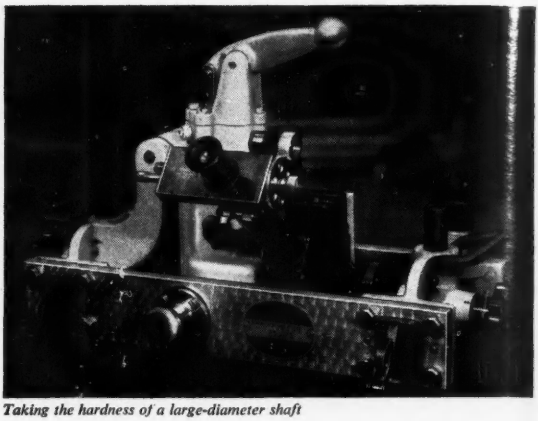

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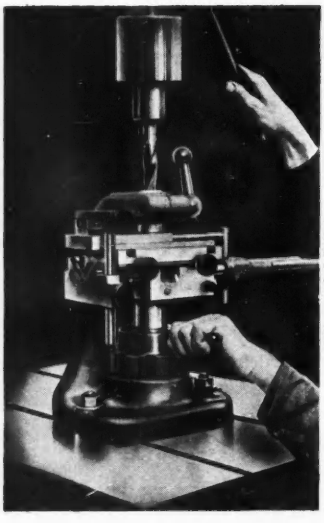

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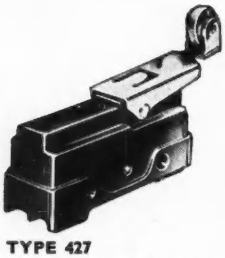

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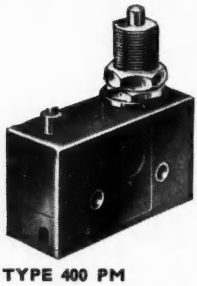

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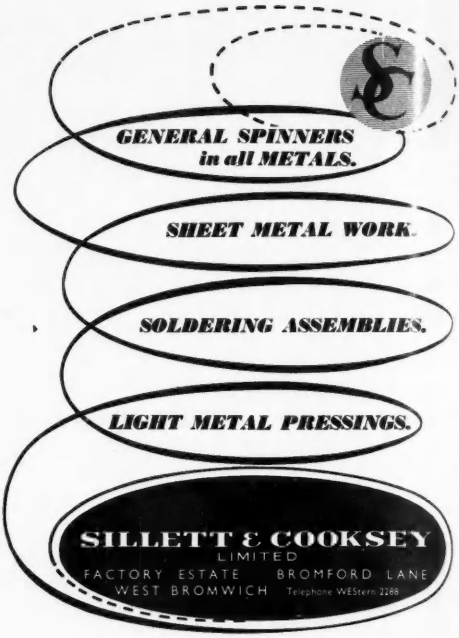

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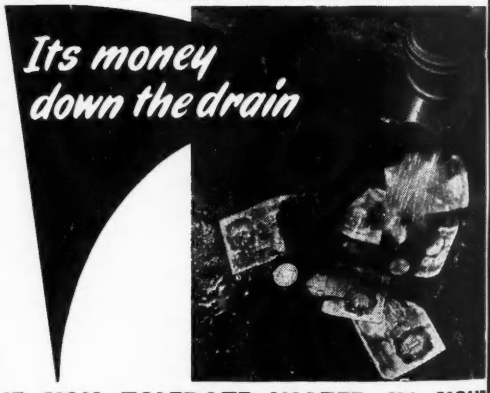

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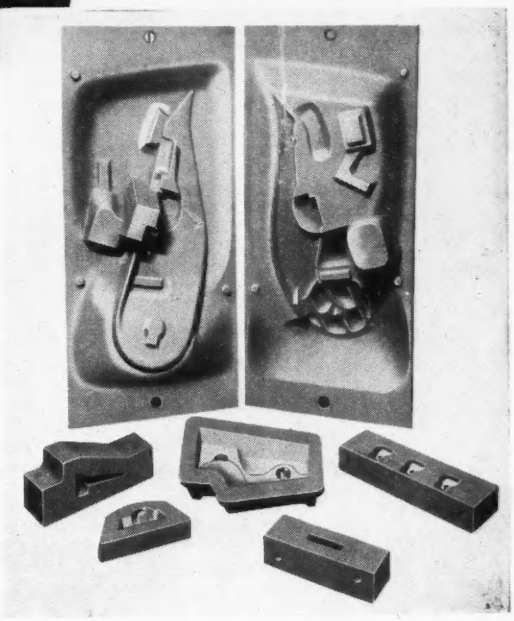

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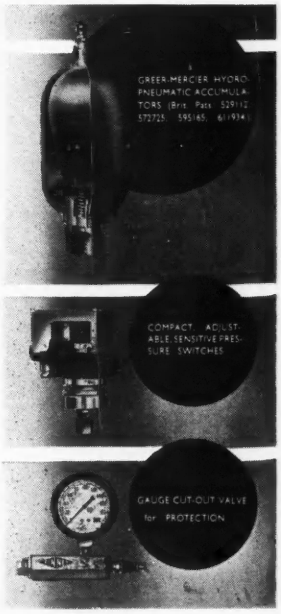
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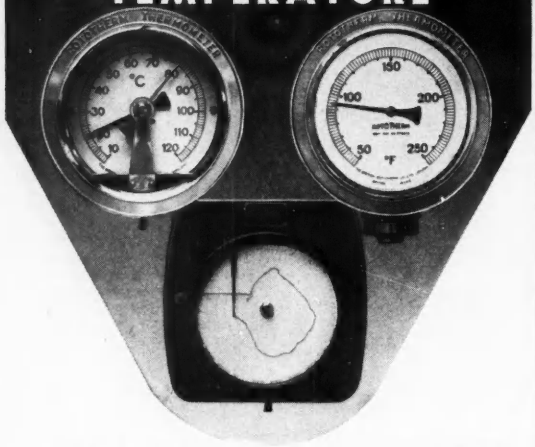

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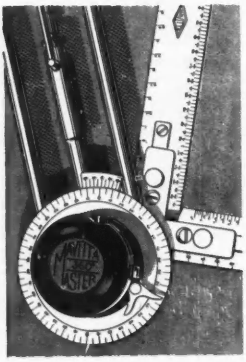

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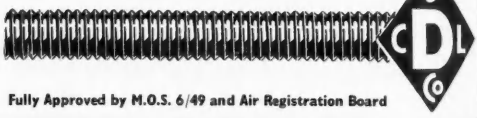

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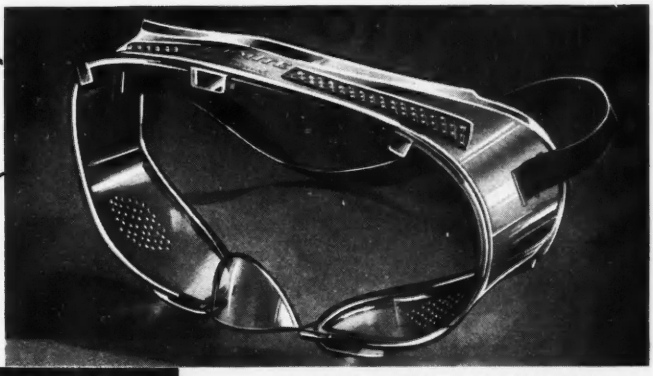

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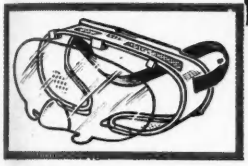

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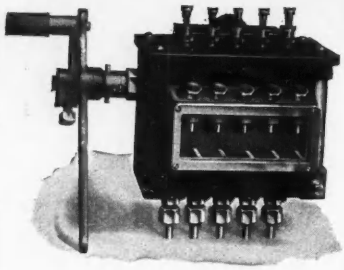

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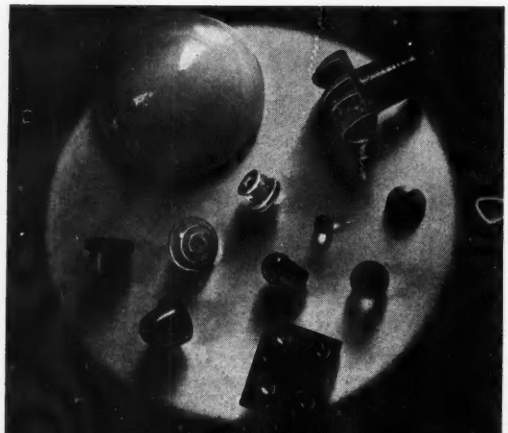

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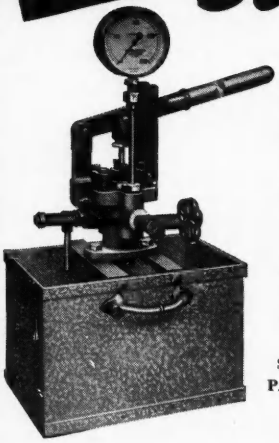

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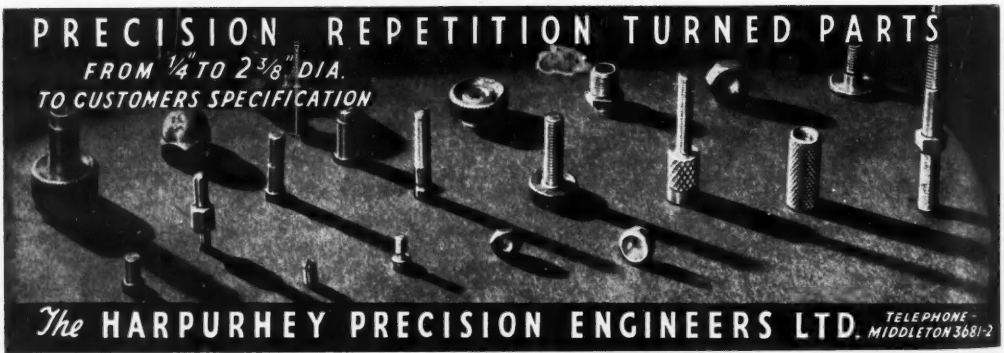

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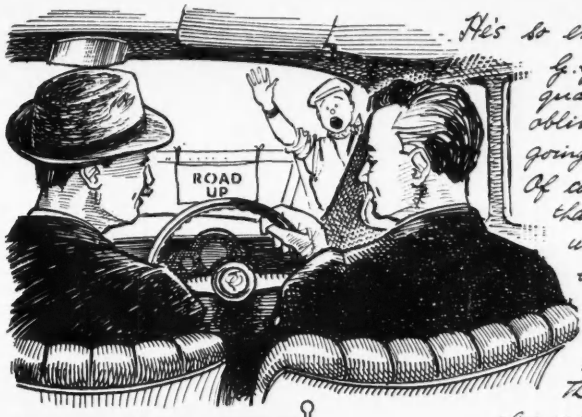

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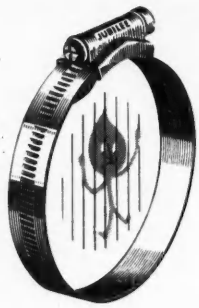

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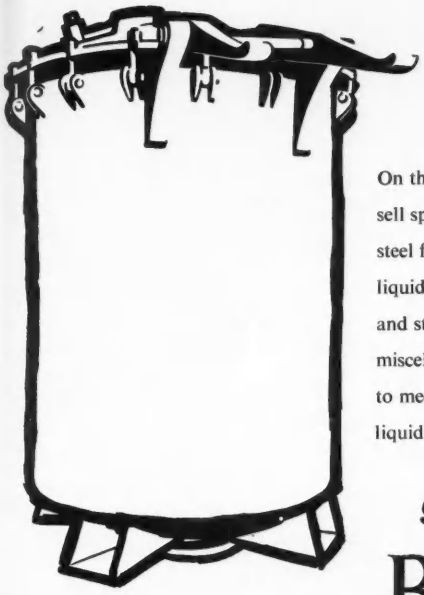

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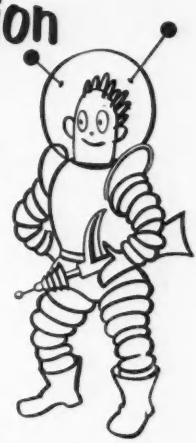

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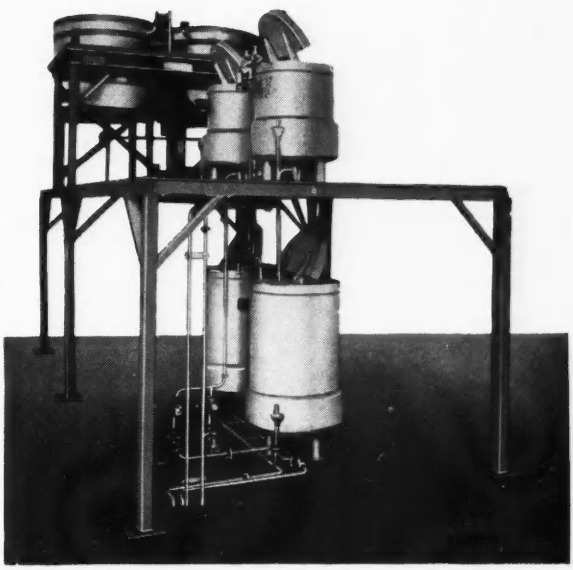

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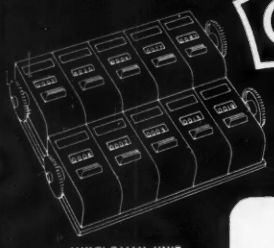
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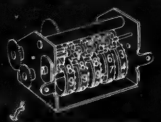
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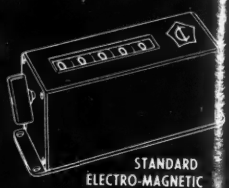
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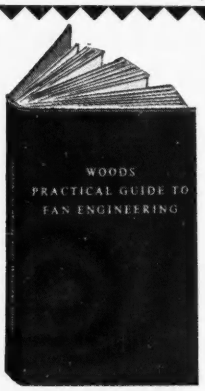

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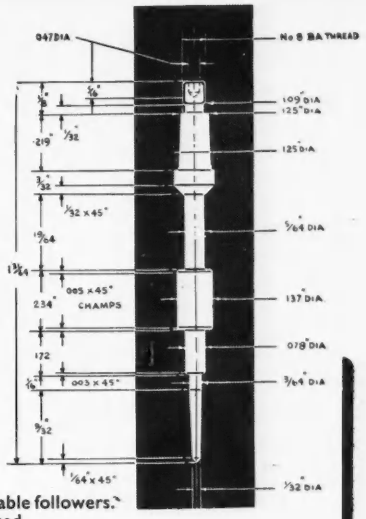

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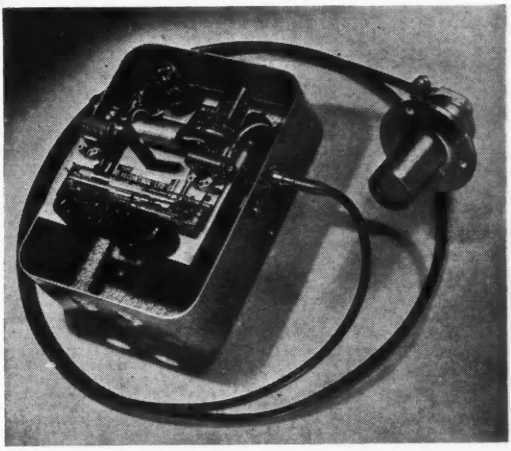

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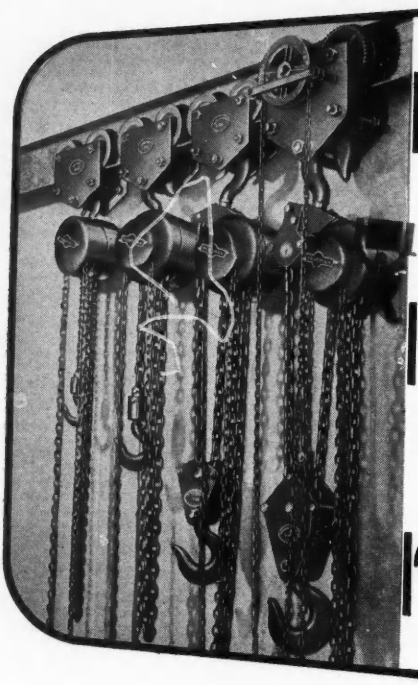

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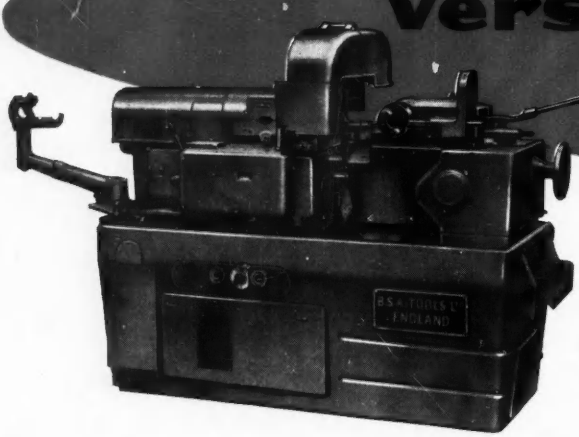

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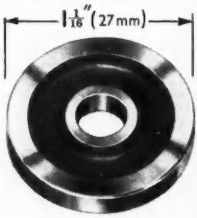

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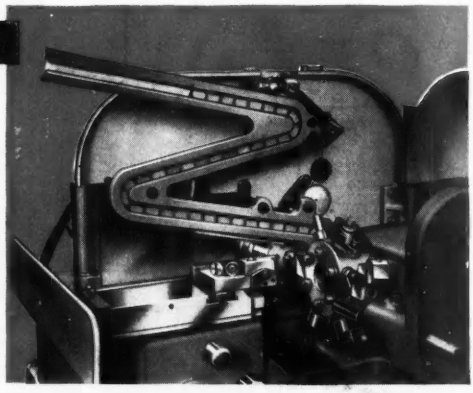

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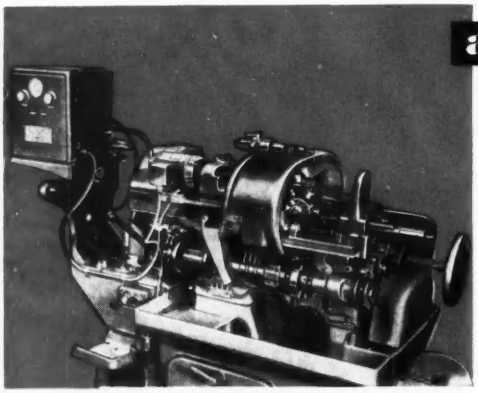

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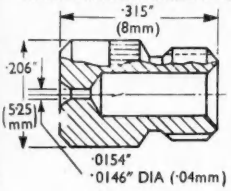

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